BRITISH COLUMBIA ACID MINE DRAINAGE TASK FORCE

Canada

BC

KUTCHO CREEK PROJECT
ACID GENERATION TESTWORK
PHASE II

Re can Environmental Services Limited
Vancouver, British Columbia

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1 - Introduction

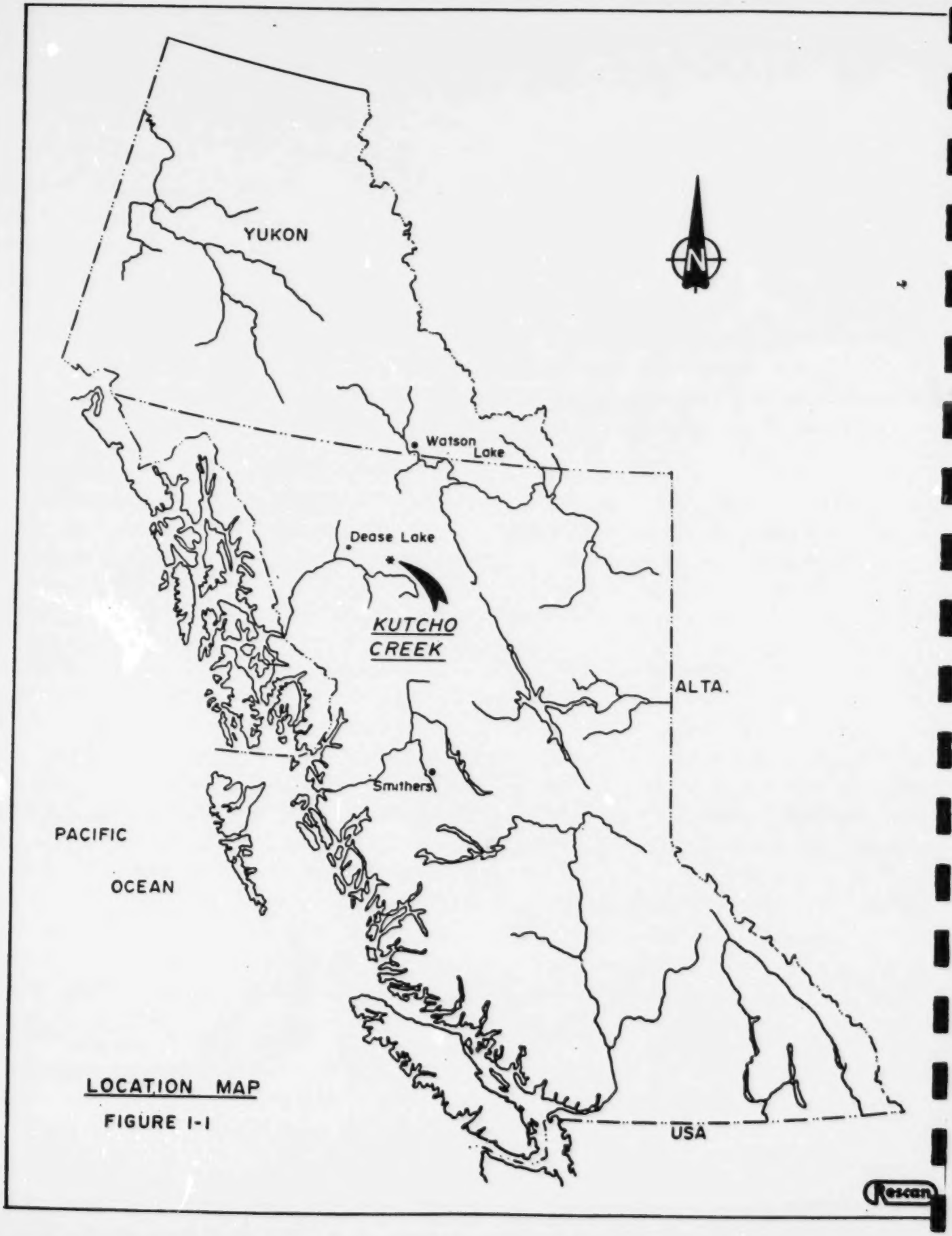
1.0 INTRODUCTION

The Kutcho Creek Property, located 100 km east of Dease Lake, British Columbia, consists of a copper-zinc-silver-gold massive sulphide deposit which is presently held under separate but adjoining mineral claims by Sumac Mines Ltd. and Homestake Development Co. (Figure 1-1). The Kutcho Creek Project is a joint venture between Sumac and Homestake, who recently acquired mineral claims previously owned by Esso Minerals Canada. When this acid generation study was initiated, Esso was the operator of the joint venture. Sumac became the new operator following the transfer of Esso's mineral claims to Homestake.

The Stage II Environmental Impact Study Report, submitted to the British Columbia Mine Development Steering Committee in March 1986, was found to be inadequate with respect to several issues and has accordingly delayed project "approval-in-principle". The present acid generation testwork being performed by Rescan Environmental Services Ltd. is an attempt to resolve these outstanding issues through development of a comprehensive acid mine drainage plan which would prevent acidic drainage both during active mining and after reclamation and abandonment of the mine site.

The Kutcho orebody, being a deposit of volcanogenic massive sulphides in close proximity to felsic and carbonate-rich ash tuffs, offers a unique opportunity to study the potential benefits of blending acid-producing footwall waste rock with acid-consuming waste rock from the hanging wall. Thus, the Kutcho acid generation testwork program was viewed by various government agencies as having significant potential for acquiring knowledge on possible mitigation strategies for the prevention of acid mine drainage for reactive mine wastes disposed in a northern environment. For this reason, the Mineral Opportunities Program of the Canada-British Columbia Mineral Development Subsidiary Agreement funded approximately 30% or $25,000.00 of Phase I. The Mineral Opportunities Program is jointly funded by the Government of Canada through the Department of Energy, Mines and Resources and the Government of British Columbia through the Ministry of Energy, Mines and Petroleum Resources.

Rescan proposed a three-phased acid generation testing program with Phase I involving a general reconnaissance survey of the Sumac exploration adit for evidence of acid generation and sampling of rock from inside the adit. Samples were cut from the wall of



LOCATION MAP

FIGURE 1-1

the adit along its 225 m length, which represents a typical cross-section of the proposed open pit. All the various lithologies were sampled, including the hanging wall units, the massive sulphide ore zone, and the footwall material.

A series of kinetic weathering tests using humidity cells charged with various individual rock types was performed. Humidity cell tests were carried out on twenty samples for a duration of 20 weeks. The testwork was completed in the latter months of 1989 and a final report for Phase I completed in November 1989.

Phase II testing involved the construction and implementation of twenty-tonne field test plots to examine whether blending acid-generating footwall wastes with acid-consuming wastes would prevent acid generation from occurring in field-scale waste dumps. This report presents preliminary results only, since the field tests were set-up just prior to the on-set of winter conditions at the site.

Humidity cell testwork was also completed in the laboratory on six samples blended with the same ratio of acid generating: acid consuming rock as those ongoing in the field.

As well, acid base accounting (ABA) tests were performed on an additional fifty core samples selected in the field representing lithologies in the Kutcho project area. Results of these tests are reported herein.

Phase III of the research test program will involve the detailed monitoring of field test dumps, including sampling of drainage water and collection of climatic data.

2 - Acid Base Accounting

2.0 ACID BASE ACCOUNTING

Acid-base accounting attempts to determine the net-neutralization potential (NNP) of a waste material by examining the balance between acid-producing components (primarily pyrite, FeS_2) and acid-consuming components (carbonates and other rock types capable of neutralizing strong acids). It is a static test which is often used as a first step in the identification of acid-generation potential in a rock sample, but does not provide information on the rate of acid production or on the quality of the resulting drainage.

2.1 Background

Acid-base accounting (ABA) tests determine the potential acid production of a rock by multiplying the total sulphur content by a conversion factor of 31.25 to estimate the maximum potential acidity (MPA) in units of tonnes of $CaCO_3$ equivalent per thousand tonnes of rock (t $CaCO_3$ eq/1000 t). This conversion factor is based on the stoichiometric equation of pyrite oxidation assuming that oxygen alone is responsible for oxidizing pyrite and that acid is generated through both complete sulphide oxidation to sulphate and precipitation of iron as $Fe(OH)_3$. Sulphide-sulphur in ABA tests is distinguished from other non acid-generating forms of sulphur such as gypsum, which can be leached with hydrochloric acid, and non-leachable sulphate such as barite.

Neutralization potential (NP) is also an important characteristic of the rock and is analyzed in ABA tests by adding an excess amount of hydrochloric acid to a sample of known weight and lowering the pH to less than 2. The excess acid dissolves not only the carbonate minerals which are capable of neutralizing acid and returning the pH to 7.0 - 8.0, but also weakly neutralizing aluminum hydroxide and iron hydroxide minerals which can restore the pH to 3.0 - 5.0. After the completion of the reaction between the acid and the sample, the quantity of acid consumed is determined by titrating the residual acid to a pH of 7.0 with standardized sodium hydroxide. During the hydroxide titration, a proportion of these dissolved minerals likely re-precipitates but the remainder, which does not re-precipitate, results in an over-estimation of the carbonate-base neutralization potential (NP). Consequently, the value obtained in a NP test is a general measure of a sample's ability to consume acid and does not reflect that the actual acid consumption potential is likely to vary depending on the final pH attained during neutralization.

Net neutralization potential (NNP) is defined as the difference between neutralization potential (NP) and maximum potential acidity (MPA). The application of NNP for prediction of acid generation must be done with caution, because net neutralization is a combination of two independent variables, namely MPA and NP. Consequently, proper interpretations of ABA results may require separate examinations of MPA and NP. Samples with low NNP are considered to be potential acid producers when exposed to oxygen and moisture in the natural environment.

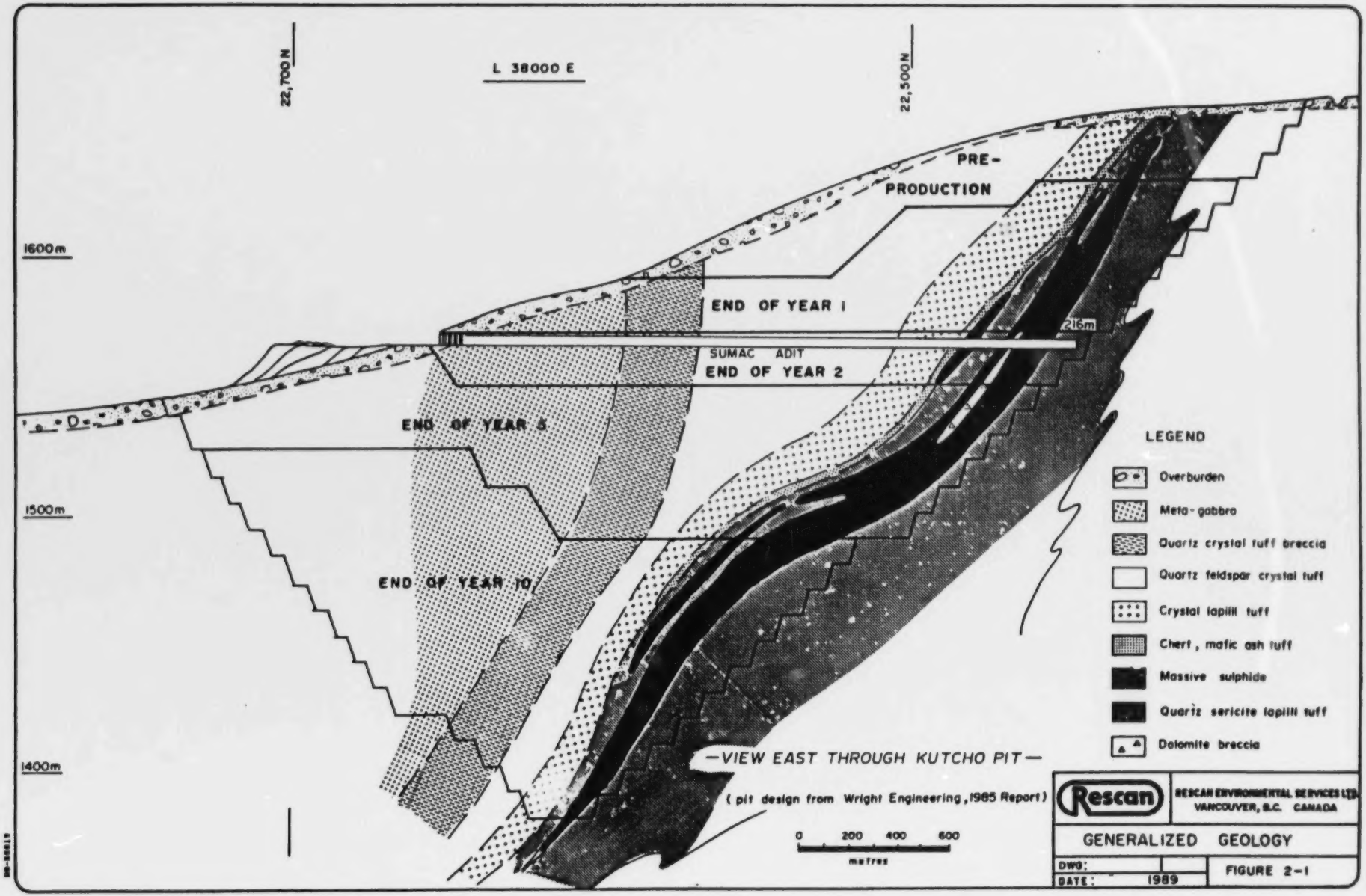
Paste pH is a general indicator of any acid generation that has occurred in the sample prior to analysis, and the reactivity of neutralizing minerals. A value of paste pH between 6.0 and 9.0 often indicates the presence of reactive carbonate minerals, such as calcite. The absence of fast-acting acid or base reactions with deionized/distilled water in the commercial laboratories operating in the greater Vancouver area is usually exhibited by a pH of 5.0 to 7.0. A paste pH measuring below pH 5.0 generally indicates that some acid generation has occurred in the sample prior to testing, and also that the sample's NP is low or is not readily available. When carbonates are present in reasonable quantities, however, they are usually sufficiently reactive to exhibit a correlation between paste pH and NP.

2.2 Methodology

The major objective of acid-base accounting testwork was to obtain ABA analyses for all major rock lithologies from the Kutcho area for which little previous ABA information was available.

Samples were collected from drill core stored in open core racks located on site. Most of the core had been exposed to weathering conditions for up to five years and evidence of previous acid generation were noted on most samples.

An attempt was made to collect a representative sample of all general lithologies east to west through the main deposit area. Sample intervals were determined using geological cross-sections and plan maps supplied by Sumac and Homestead. Figures 2-1 and 2-2 show the general geological cross-section and plan map of drill-hole sample locations, respectively. Table 2-1 details sample selection.


22,700 N
L 38000 E
22,500 N
PRE-
PRODUCTION
1600m
END OF YEAR 1
216m
SUMAC ADIT
END OF YEAR 2
END OF YEAR 5
1500m
END OF YEAR 10
1400m
—VIEW EAST THROUGH KUTCHO PIT—
(pit design from Wright Engineering, 1985 Report)
0 200 400 600
metres
LEGEND
Overburden
Meta-gabbro
Quartz crystal tuff breccia
Quartz feldspar crystal tuff
Crystal lapilli tuff
Chert, mafic ash tuff
Massive sulphide
Quartz sericite lapilli tuff
Dolomite breccia
Rescan
RESCAN ENVIRONMENTAL SERVICES LTD.
VANCOUVER, B.C. CANADA
GENERALIZED GEOLOGY
DWG:
DATE: 1989
FIGURE 2-1

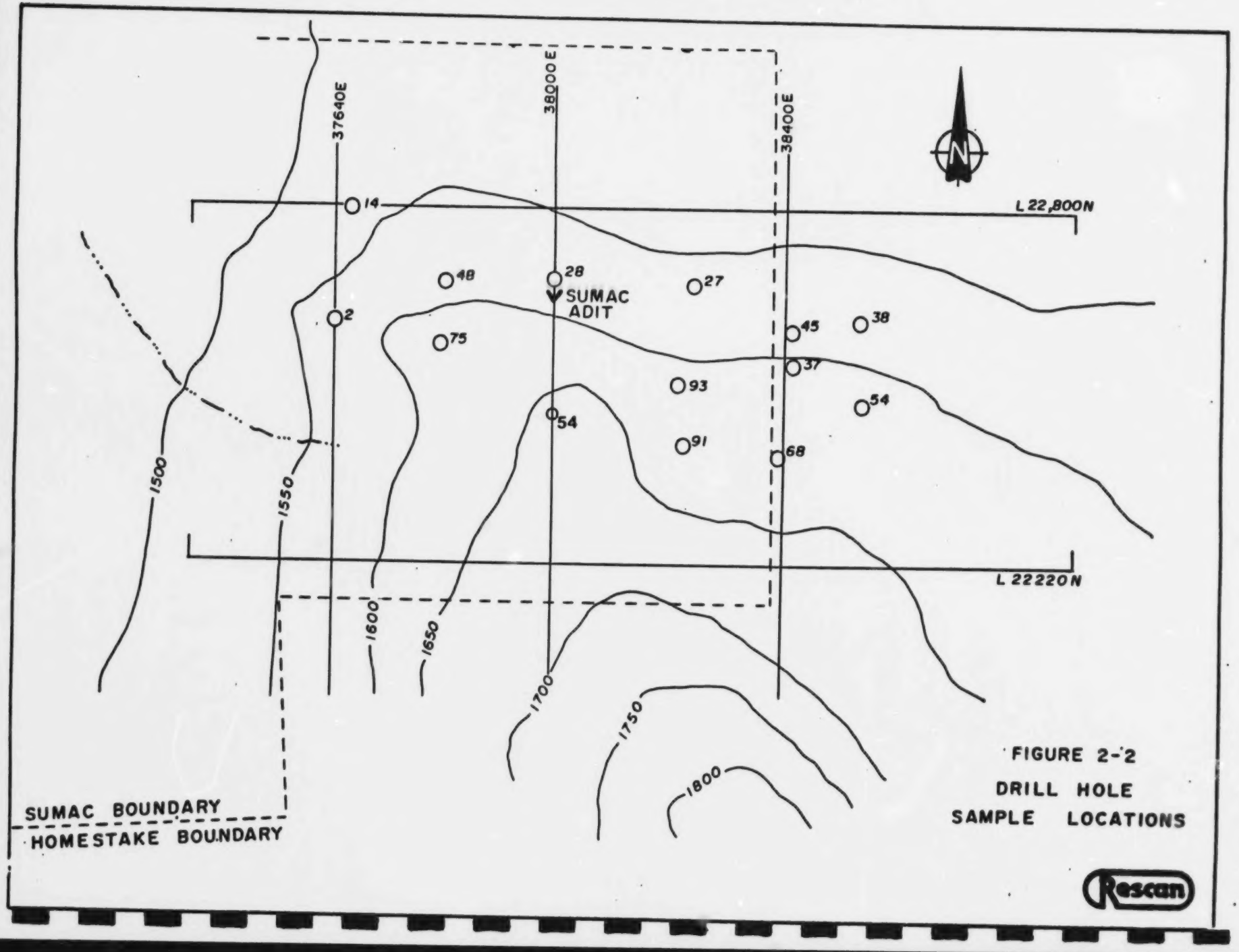


FIGURE 2-2

DRILL HOLE

SAMPLE LOCATIONS

Rescan

Table 2-1

Sample Selection for Acid Base Accounting

Drill Hole	Section	To metres	From metres	Length metres	Lithology	Sample #
Homestake 54	38520E	27.0	27.7	0.7	QFXT	1
		51.0	51.8	0.8	QFXT	2
		58.5	59.0	0.5	QFXT (HW)	3
Homestake 68	38400E	31.7	32.3	0.6	ORE	4
		46.0	46.6	0.6	SQLT (FW)	5
Homestake 37	38400E	44.2	44.8	0.6	QFXT	6
		90.5	91.1	0.6	ASHT (HW)	7
		108.2	108.8	0.6	ORE	8
Homestake 38	38520E	17.4	17.9	0.5	GABR	9
		47.9	48.5	0.6	QXTB	10
		92.9	93.6	0.7	QFXT	11
		136.5	137.4	0.9	ASHT (HW)	12
Homestake 45	38400E	20.4	21.0	0.6	GABR	13
		59.4	60.0	0.6	QFXT	14
		111.8	112.5	0.7	QFXT	15
		135.6	136.2	0.6	ASHT	16
		185.0	185.6	0.6	SQLT	17
Sumac 2	37640	12.8	13.7	0.9	QXTB	18
		36.9	37.5	0.6	QFXT	19
		47.9	48.5	0.6	ASHT (HW)	20
		64.6	65.2	0.6	ASHT (FW)	21
Sumac 54	38000E	22.9	23.5	0.6	QXTB	22
		60.0	60.6	0.6	QFXT	23
		77.4	78.0	0.6	ASHT (HW)	24
Sumac 28	38000E	54.3	54.9	0.6	GABR	25
		99.7	100.3	0.6	QXTB	26
		130.8	131.4	0.6	ASHT (HW)	27
		179.8	181.3	1.5	SQLT (FW)	28

Table 2-1 (cont'd)

Drill Hole	Section	To metres	From metres	Length metres	Lithology	Sample #
Sumac 14	37640E	13.7	14.3	0.6	GABR	29
		82.3	82.9	0.6	QXTB	30
		131.9	132.6	0.7	ASHT (HW)	31
		168.8	169.7	0.9	ORE	32
		190.5	191.4	0.9	SQLT (FW)	33
Sumac 27	38240E	64.6	65.2	0.6	GABR	34
		142.9	143.5	0.6	CXLT	35
		160.3	160.9	0.6	CXLT	36
		166.7	167.3	0.6	ORE	37
		191.4	192.6	1.2	SQLT	38
		197.5	198.1	0.6	SQLT	39
Sumac 48	37760E	10.9	11.6	0.7	GABR	40
		57.9	58.8	0.9	CXLT	41
		118.6	119.8	1.2	ORE	42
Sumac 75	37760E	2.4	3.0	0.6	GABR	43
		29.9	30.4	0.5	CXLT	44
		65.8	66.4	0.6	ORE	45
		77.7	78.6	0.9	SQLT	46
Sumac 91	38240E	8.8	9.4	0.6	CXLT	47
		27.7	28.9	1.2	ORE	48
Sumac 93	38240E	45.7	46.3	0.6	CXLT	49
		109.4	110.9	1.5	ORE	50

Samples were taken from both Sumitomo and Esso drill core.

Abbreviations:

GABR = Meta Gabbro
QXTB = Quartz Feldspar Tuff Breccia
QFXT = Quartz Feldspar Crystal Tuff
CXLT = Crystal Lapilli Tuff
ASHT = Ash Tuff
SQLT = Sericite Quartz Lapilli Tuff
HW = Hanging Wall
FW = Footwall

There are five major rock groups that will be represented in the rock pile; Meta-gabbro, Quartz crystal tuff breccia, Quartz feldspar crystal tuff/crystal lapilli tuff, Mafic ash tuff, and Quartz sericite lapilli tuff. A total of 50 samples representing these major rock types have been examined in ABA tests. The general procedures recommended by the US-EPA were followed for ABA testwork, and are summarized in Appendix A.

All samples were dried, crushed and pulverized until they passed through a #140 mesh. After being homogenized with distilled water into a paste (at a 2:1 mixture of sample to water), the pH of the paste was measured as an indication of the sample's reactivity and its freshness.

Potential acid-generating reactive sulphide-sulphur was determined by subtracting all forms of non-reactive sulphur from the total sulphur contained in the sample. Total sulphur content was analyzed using a LECO furnace. A split sample was reacted with hydrochloric acid (HCl) in order to extract the sulphate-sulphur prior to a LECO furnace total sulphur assay. The quantity of reactive sulphide-sulphur was then calculated by taking the difference between the total sulphur and sulphate-sulphur. In many of the core samples selected, in which oxidation or acid generation was evident, it is probable that not all the sulphate present is due to non-reactive forms of sulphur but from sulphides which have already undergone oxidation.

2.3 Results

The results of ABA testwork for the Kutcho core samples are summarized in Table 2-2 and presented in detail in Appendix B. Test results include measurements for paste pH, total sulphur, maximum potential acidity, neutralization potential, $CaCO^3$ (as CO^2), sulphate and sulphide.

Analysis of sulphur forms indicates that most sulphur in the rock (73%) exists as potentially reactive sulphide-sulphur.

Neutralization potential reported in equivalents of $CaCO_3$, represents the capacity of the rock to consume acid. All mean values of neutralization potential for samples are relatively high, ranging from 60.1 to 187 t $CaCO_3$/1000 t of rock. A clear relationship exists between paste pH and neutralization potential as shown in Figure 2-3, which indicates that significant levels of neutralization potential are reactive and result in

Table 2-2

Summary of ABA Testwork

Waste Rock	n	Paste pH			Total S(%)			Max. Pot. Acidity $tCaCO_3/1000t$			NP $tCaCO_3/1000t$			NNP $tCaCO_3/1000t$		
		min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean
Gabbro	6	8.5	9.5	8.9	0	0.55	0.15	0	17	4.7	99	300	187	94	294	182
Quartz Crystal Tuff Breccia	8	7.4	9.4	8.8	0	6.84	1.73	0	214	54.4	22	422	183	-145	421	128.8
Quartz Felspar Crystal Tuff/ Crystal Lapilli Tuff	15	5.7	9.6	8.85	0	16.5	1.33	0	516	41.6	3	566	121.1	-513	553	79.4
Ash Tuff	5	8.8	9.4	9.12	0	0.186	0.08	0	6	2.8	42	141	66.4	38	138	63.6
Sericite Quartz Lapilli Tuff	7	5.7	8.2	7.28	2	36.2	17.0	63	1130	553	-1	181	60.1	-955	54	-473.4

NP = Neutralization Potential
NNP = Net Netralization Potential

alkaline pH. In most cases, the carbonate content accounts for most of the neutralization potential as shown in the linear relationship of Figure 2-4.

Paste pH provides a preliminary assessment of the presence of residual acid due to acid generation prior to testing. Relationships between paste pH and net neutralization potential and paste pH maximum potential acidity (Figures 2-5 and 2-6, respectively) indicate that samples with high levels of sulphur are more reactive, as commonly seen in the Quartz sericite lapilli tuff footwall rocks.

Based on paste pH vs. leachable sulphate (Figure 2-7) it appears that: 1) only the Quartz sericite lapilli tuff shows indications of significant prior oxidation resulting in a relatively acidic pH; 2) most of the samples have had little oxidation of sulphide to sulphate prior to analyses; and, 3) of the few samples which show elevated sulphate levels (lapilli tuff footwall rocks) a near neutral pH, through neutralization, has been maintained.

No relationship was noted between ABA parameters vs. hole location. This suggests that the rock type is the dominate control on acid generation behavior. In the footwall lapilli tuffs neutralization potentials were low compared to maximum potential acidity, and are expected to generate acid, whereas neutralization potentials are generally high for hanging wall rocks and thus have the potential to consume acid. To place ABA analysis of the Kutcho rocks into perspective, Table 2-3 shows the estimated volumes of acid generating rock and acid consuming rock that will comprise the waste dump material at the pre-production year, 1st, 2nd, 5th and 10th year of mine development.

Based on the relative proportions of acid consuming and acid generating materials, the potential exists for acid drainage through the excess of acid producing materials on site.

Blending of waste rock, certainly in the initial stages of mine development will not be a efficient control of acid drainage and a combination of measures will have to be looked at to achieve the most beneficial and cost effective means to control acid drainage.

After the mine is closed, flooding of the Kutcho pit and disposing the acid generating waste material into the pit would probably be the most effective abatement measure to control acid generation from the Kutcho waste rock. However, because Kutcho will be a single pit operation, it will be necessary to store the reactive waste rock produced during the life of the mine until it can be moved back into the pit.

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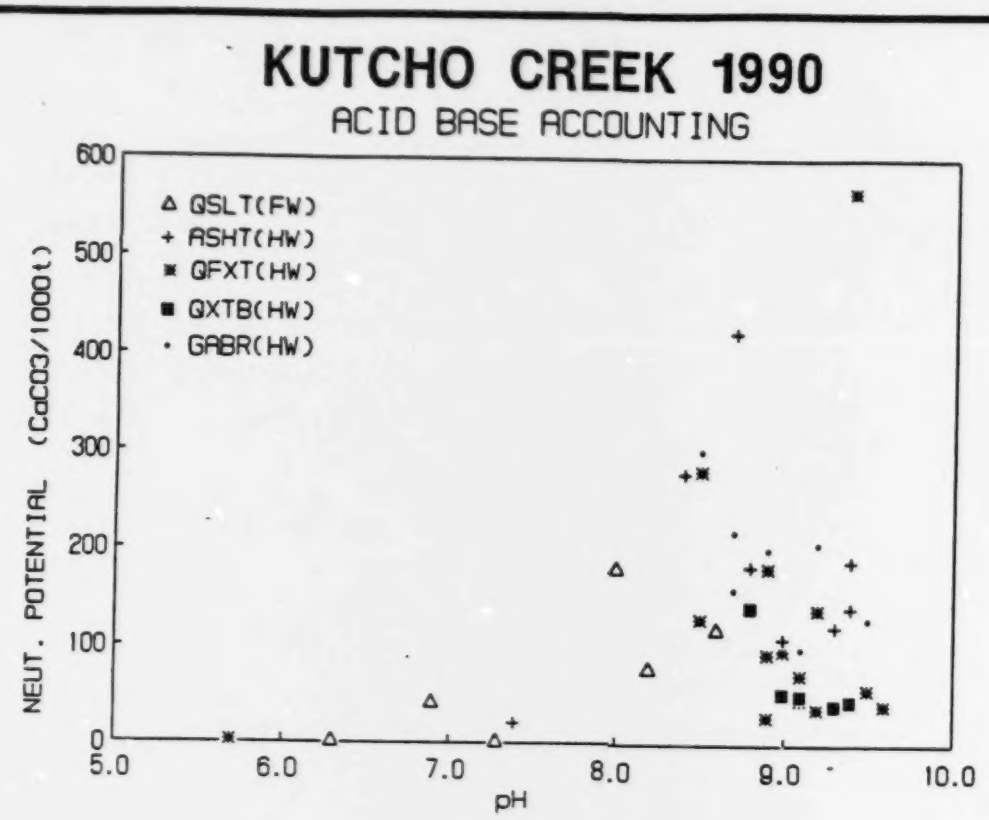
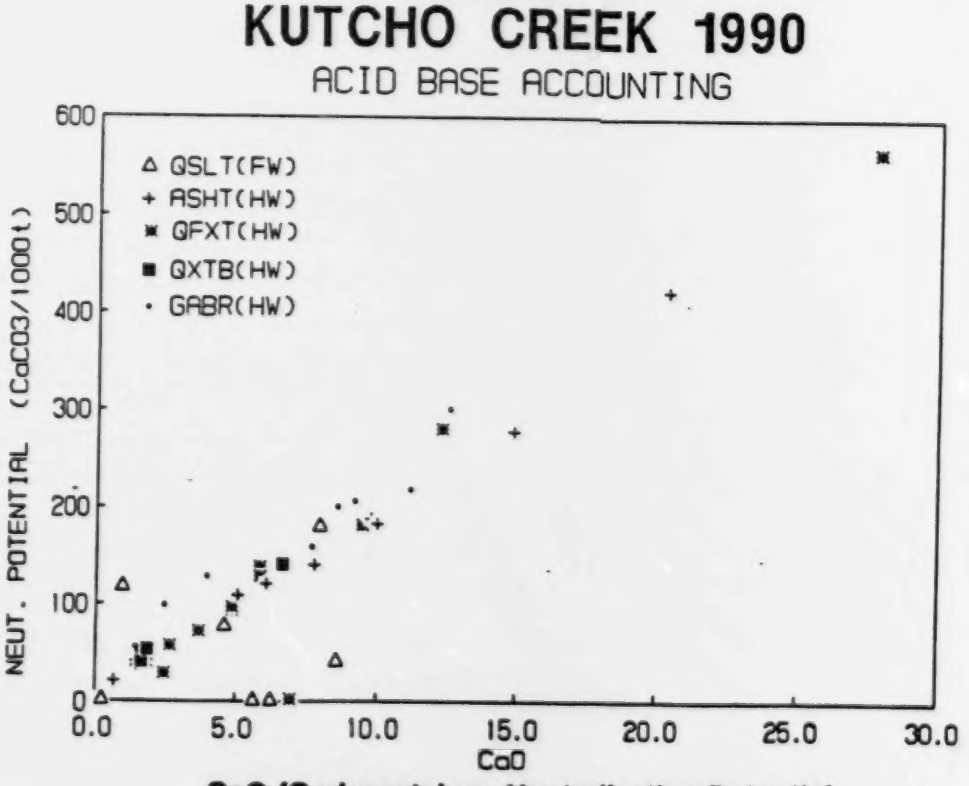
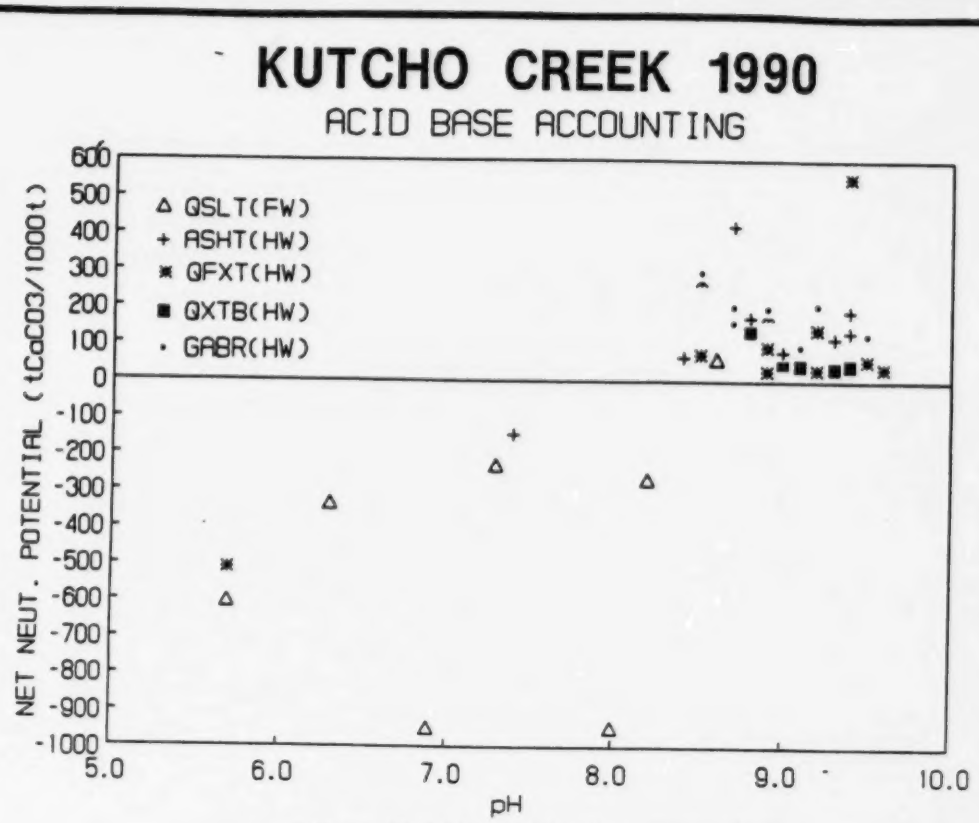


pH vs. Neutralization Potential
Figure 2-3

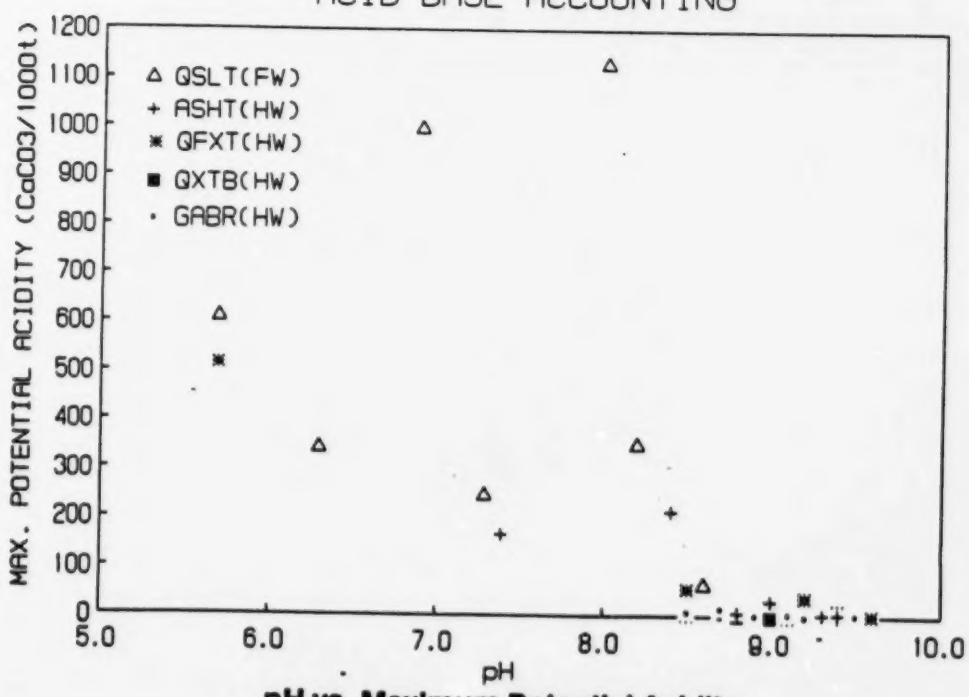


CaO (Carbonate) vs. Neutralization Potential
Figure 2-4



pH vs. Net Neutralization Potential

Figure 2-5



pH vs. Maximum Potential Acidity

Figure 2-6

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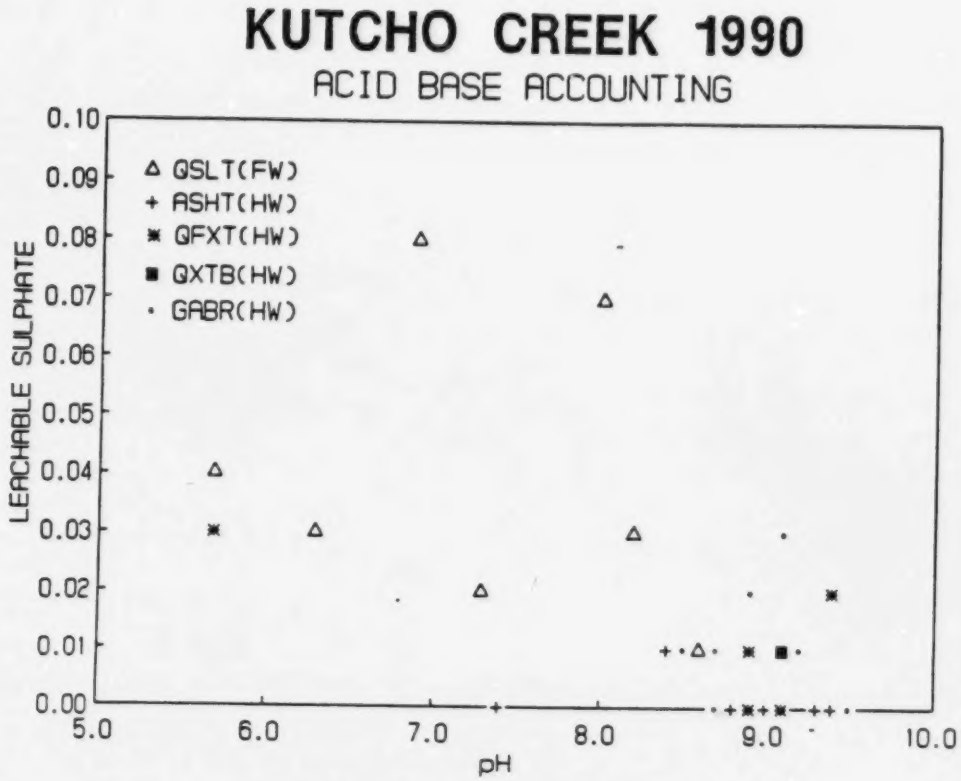


pH vs. Leachable Sulphate

Figure 2-7

Table 2-3

Accounting of Acid Generating and Acid Consuming Waste Rock to be Mined at Kutcho

Mine Stage Year	Gabbro NNP = 182	Ash Tuff NNP = 128.7	Crystal Tuff NNP = 71.5	Sericite Quartz Lapilli Tuff NNP = 493.4	Total
PPD	(72.0) ***13104	(554.1) 71312	(7283.3) 0.52 x 10^6	(2090.6) -0.99 x 10^6	** -0.38 x 10^6
1	(1323.0) 240786	(1179.7) 151827	(4889.8) 0.35 x 10^6	(1601.5) -0.76 x 10^6	** -0.01 x 10^6
2	(1125.5) 204841	(1219.2) 156911	(5988.1) 0143 x 10^6	(1155.1) -0.55 x 10^6	0.24 x 10^6
5	(9473.0) 1.72 x 10^6	(2563.8) 0.33 x 10^6	(14261.7) 1.02 x 10^6	(1346.5) -0.64 x 10^6	2.41 x 10^6
10	(9910.1) 1.80 x 10^6	(6265.0) 0.81 x 10^6	(16885.8) 1.21 x 10^6	(2904.1) -1.37 x 10^6	2.44 x 10^6
Total	(21903.7)	(11781.8)	(49300.6)	(9097.9)	

** = Excess acid generating waste rock
(72.0) tonnes of rock material to be mined (P. Holbeck, Homestake)
***13104 = NNP x (tonnes of rock material)
NNP = Net neutralization potential
PPD = Pre production year

One temporary control method would be to add excess neutralizing material, particularly a carbonate compound which produces a neutral to alkaline pH in associated waters. Limestone is suggested as there is a limestone deposit near the minesite, (pers. communication P. Holbeck, Homestake) that can be quarried, crushed and transported at relatively low cost. Waste materials could then be mixed at pre-determined ratios and stored on a suitable stockpile facility built with a confining dyke and catchment area in which associated waters may be monitored and treated if necessary, before being released into the environment.

Covering or sealing the waste material may also be considered as a short term control of acid drainage. There are a variety of materials such as soil covers, synthetic membranes, cement etc. which may be considered. Each method will have an associated cost and should be compared to option 1 for cost effectiveness. Again a suitable stockpile facility should be constructed for the purpose of controlling and monitoring acid generation.

3 - Humidity Cell Testwork

3.0 HUMIDITY CELL TESTWORK

Results of the acid-base accounting testwork suggests a potential for acid generation from the footwall rocks and acid consumption from the hanging wall rocks at Kutcho. ABA analyses, however, provides information on the potential for acid generation or acid consumption but it cannot determine if it will indeed occur, if so, or at what rate. As previously suggested, blending of footwall and hanging wall rocks may be a viable method for controlling net acid generation at Kutcho. To test the viability of blending potentially acid-generating waste rock with potentially acid-consuming waste rock, large-scale field test piles complimented with small-scale laboratory humidity tests were initiated in August 1989.

3.1 Large-Scale Field Test Piles

Phase II of the Kutcho research program involved the construction of three on-site field test piles. Each box was designed to hold 20 tonnes of waste rock blended to specific ratios of acid-generating:acid-consuming rock types. As described in Rescan's original proposal, pilot-scale acid generation tests on 20 tonne blended samples of waste rock have been implemented at the Sumac Adit site of the Kutcho Creek Property. The necessary size for the timber boxes was based on an assumed bulk density of the crushed rock material stored under tarps adjacent to the adit. The rock densities averaged 2.7 tonnes/m^3 and had a swell factor of 1.5. This corresponds to a total volume of 11.1 m^3 following placement into the boxes and is equivalent to a bulk density of 1.8 tonnes/m^3. Accordingly, test boxes were designed to hold 11.1 m^3 of waste rock when filled such that the upper surface is left with a pyramidal shape having a 30 degree slope angle.

Floor and height dimensions of the boxes were decided after evaluating many possible box configurations and balancing various competing interests. For example, test boxes which were large in floor area would have correspondingly low side walls, or perhaps none at all. This would create a large surface to dump area, and result in a higher flushing rate from precipitation. Boxes having a small floor space would receive much lower flushing due to rainfall, and would require much higher side walls. The dimensions of the test boxes were finalized with an inside floor area of 3.28 m by 3.28 m and a side wall height of 1.35 m. The corresponding height of the apex of the pyramid in the centre of the heap was 1.67 m.

The floor system is based on 3 x 10 joists placed on 16 inch centres, and securely nailed to three 10 x 10 inch skids, as shown in Plate 3-1. A three-layered plywood floor (totalling 2.25 inches in thickness) was glued and lag bolted to the joists. Wood preservative was applied to the skids, joists and floor to prevent premature degradation of the boxes in the event that monitoring is carried out for a longer period than is currently anticipated.

The walls of the test boxes were designed to permit the natural circulation of air into the sides of the waste material. An outer frame was built using 4 x 4 plates on the top and bottom. Inside this frame, an inner wall was built-up using 2 x 4's placed on the flat with 2 inch spacers in between as shown in Plate 3-2.

The floor of the test boxes was specially designed to catch runoff and direct the flow to water sampling buckets. Wedge-shaped spacers were fixed on top of the floor joists to impart a 2% slope towards the centre of the box, creating a shallow V-shaped valley. The gravel pad under the box was graded to impart a 2 to 4% slope. Drainage collected in the V-shaped valley flowed downhill towards one end of the valley, where it drains into sample collection buckets.

The floor of the box was covered with a polyethylene liner. Six separate drainage areas (lysimeters) were created by gluing baffle strips onto the liner. Each of the lysimeters drained into the sample collection system through its own 1 inch (I.D) PVC conduit, as shown in Plates 3-3 and 3-4. The function of the lysimeters was to determine whether precipitation falling on the surface of the dump percolates uniformly down through the waste rock, or whether selected routes are followed potentially by-passing different zones within the dump.

Prior to filling the waste rock boxes, plastic conduits on the floor were covered with a protective wooden cover to prevent the pipes from being crushed (Plate 3-5). Nails were not used to build the covers in order to prevent contamination of drainage waters with metals. Protection of the plastic liner was provided by lining the box with a layer of non-woven geotextile, as shown in Plate 3-6. The fabric also serves to prevent the escape of waste rock through openings in the side walls. The three test boxes were loaded with waste rock according to the anticipated ratios of waste rock production at the end of pre-production and after five years of mining. The ratio of footwall siliceous pyritic tuff

Plate 3-1: Floor joists place on 16 inch centers securely nailed to 10 x 10 skids provide the foundation for 20 tonne waste rock test boxes.

Plate 3-2: Walls of the boxes were designed to permit natural circulation of air into the waste pile.

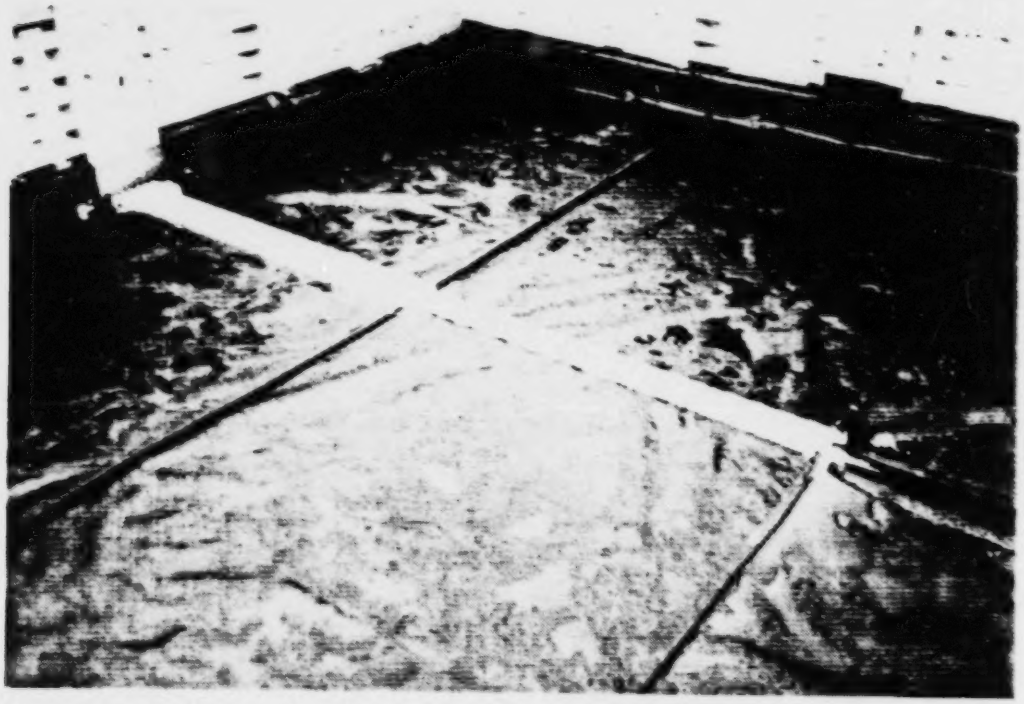


Plate 3-3: Floor of each box is divided into 6 lysimeters designed to demonstrate whether precipitation falling on the dump is percolating uniformly or selecting specific pathways.

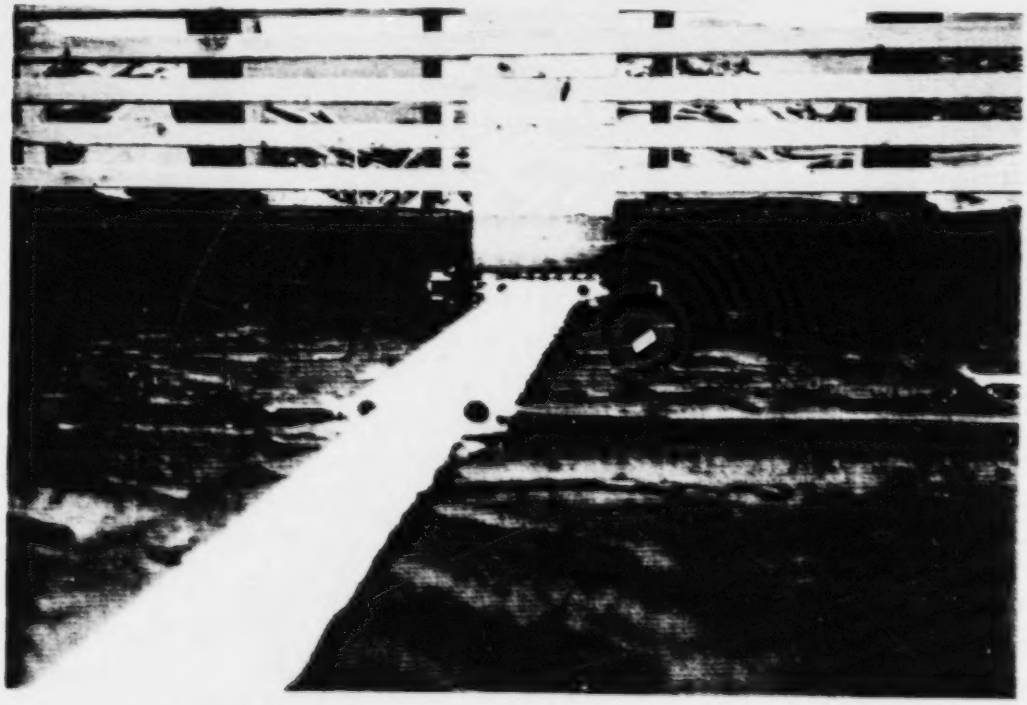


Plate 3-4: Water collection system for sampling leachate from each lysimeter area.

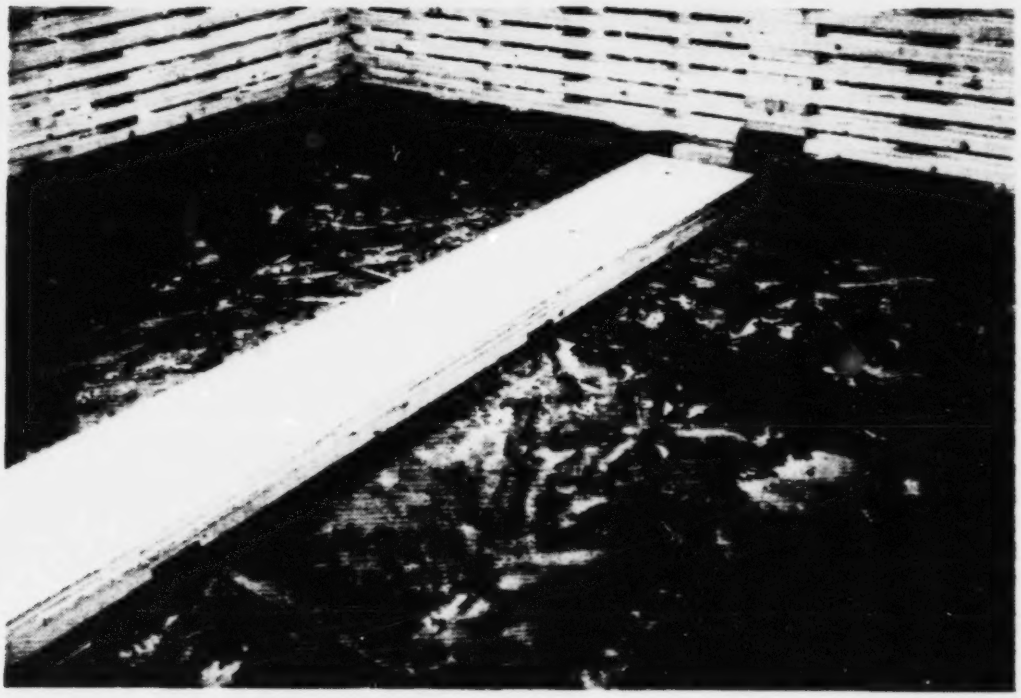


Plate 3-5: Protective wooden cover to prevent drain pipes from being crushed.

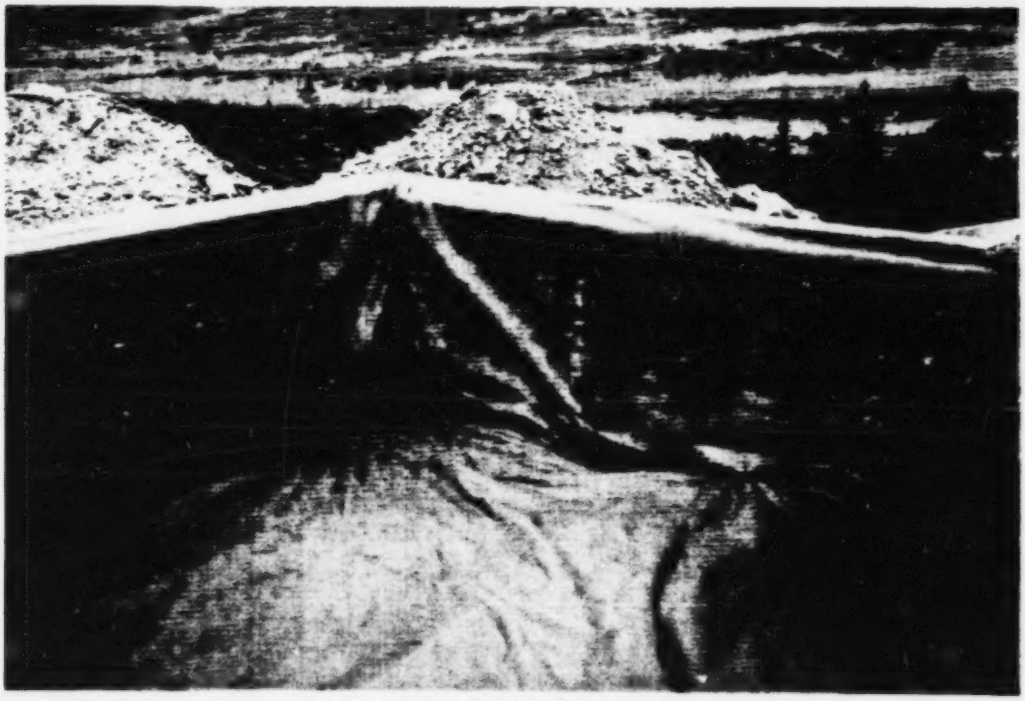


Plate 3-6: Protection of plastic liner was provided by lining the box with a layer of non-woven geotextile.

to the various non-pyritic hanging wall rock units was based on the pit production schedule, as outlined in the Wright Engineers Feasibility Report of April, 1985.

The relative quantities of the various lithologies which were blended and loaded into the test boxes are presented in Plate 3-7 as well as Figure 3-1. Sufficient quantities of meta-gabbro waste were not available, as this material had not been stockpiled during construction of the Sumac adit.

Loading the test boxes with blended waste rock was accomplished, together with the blending, in a sequential operation which was repeated until the heaps filled the boxes. One m^3 bucket of material of each waste rock was added to the box, where it was shovelled uniformly throughout the box, and mixed with the material beneath it. This method of construction was thought to be representative of the degree of blending which could reasonably be achieved through a carefully controlled mining and full-scale dumping operation. The load/blending operation was conducted on September 1 and 2, 1989.

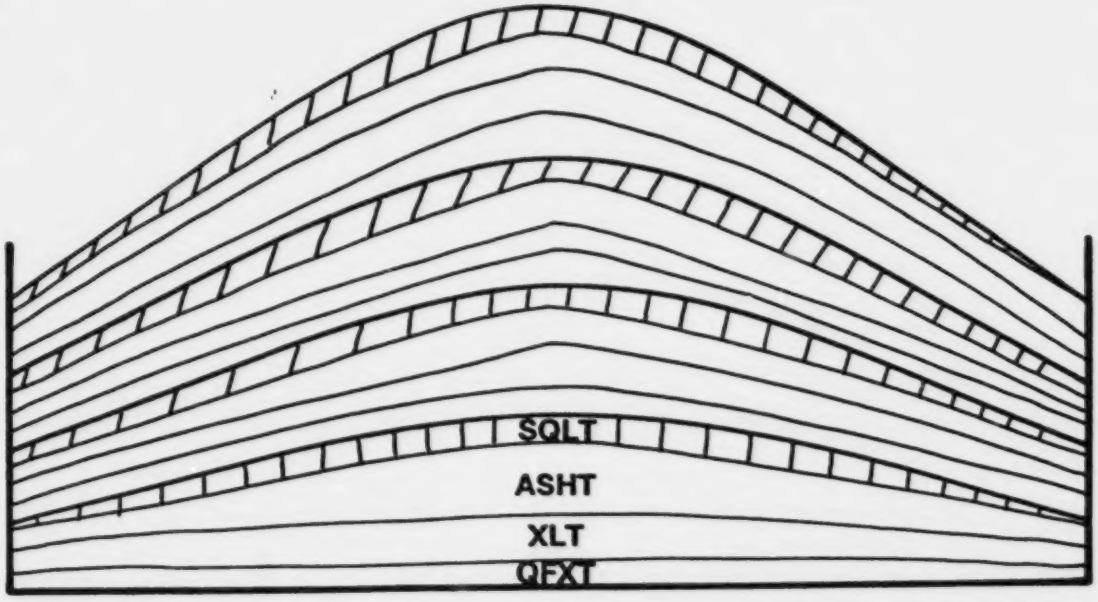
One of the two test heaps, corresponding to Year 5, was covered with a 6 inch layer of fine-grained soil removed from an area just east of the adit. Comparisons between the two 5-Year test dumps will provide information on the potential benefits of adding a soil cover to the dumps to control acid drainage.

Sampling of the effluent from the three test heaps will be performed as often as possible during non-winter months when a liquid effluent is anticipated. To date, samples of drainage water were collected only on September 28, 1989, prior to winter freeze-up.

Pile temperatures are also being continually monitored with thermistors, which were embedded with waste material in the centre of each heap. The ambient temperature of air outside the piles is also being continuously monitored by a thermistor which has been installed in a louvered Stevenson screen. This system will permit the detection of exothermic reactions occurring within the waste piles.

The oxygen content of air extracted from the centre of the heaps will also be analyzed during sampling periods. Rapid oxidation of sulphides within the piles could deplete oxygen levels below normal atmospheric concentrations. Taigon tubing was installed together with the thermistors to the centre of each pile to facilitate the withdrawing of air by an oxygen analyzer.

Diagrammatic Waste Pad Showing Layering of Blends



Lithology	Ratio of Pyritic vs. Non-pyritic	
	Preproduction (1:6)	5-Year (1:2.5)
QFXT - Quartz Feldspar Crystal Tuff	1.0	1.0
XLT - Crystal Lapilli Tuff	1.0	1.0
ASHT - Ash Tuff	1.0	0.5
SQLT - Footwall Pyritic Sericite Quartz Lapilli Tuff	0.5	1.0

Figure 3-1

Rainfall at the Sumac adit site is also being monitored with a tipping-bucket rain gauge which is mounted next to one of the test boxes, as shown in Plate 3-8. A datalogger is being used to record pile temperatures and rainfall data. Plate 3-8 shows the datalogger housed in a wooden shelter mounted between two of the test boxes. External power is supplied by a 12 volt deep-cycle battery. Recharging of the battery is performed at the site using a portable generator and battery charging unit.

Leachate water from the on-site piles was collected once, prior to winter freeze-up. Samples from each test cell were collected on September 28, 1989, and sent to ASL Laboratories in Vancouver, for metal analyses.

The leachate water was characterized by having a low pH and high concentrations of metals. These results are not unexpected as they represent the first flush of acid products of the waste stockpiles which had undergone oxidation prior to being disturbed.

3.2 Laboratory Humidity Cell Testwork

Laboratory humidity cell testwork performed on blended samples from the Kutcho project area have recently been completed for a 20 week period. Samples were collected from the same stockpiles as samples for the large scale test pads.

Each of the field test cells is represented by two humidity cells in the laboratory. The blending ratios used in each of the two sets of laboratory humidity cells are identical to those used in the field, however the contents of one set has been thoroughly rinsed with water to remove any previously produced acid products, and the other was left unrinsed.

The humidity cell test procedure involved subjecting blended rock samples to alternate cycles of moist/dry air, followed by flushing with deionized/distilled water to remove any accumulated acid products and leached metals. Wash water is subsequently collected and analyzed for products of acid generation in the rock sample.

Although this procedure provides an indication of the acid drainage characteristics of a waste material, it cannot be used to predict accurately the kinetics and equilibria of the oxidation and neutralization reactions taking place in the natural environment.

Plate 3-7: Blended waste rock test boxes.

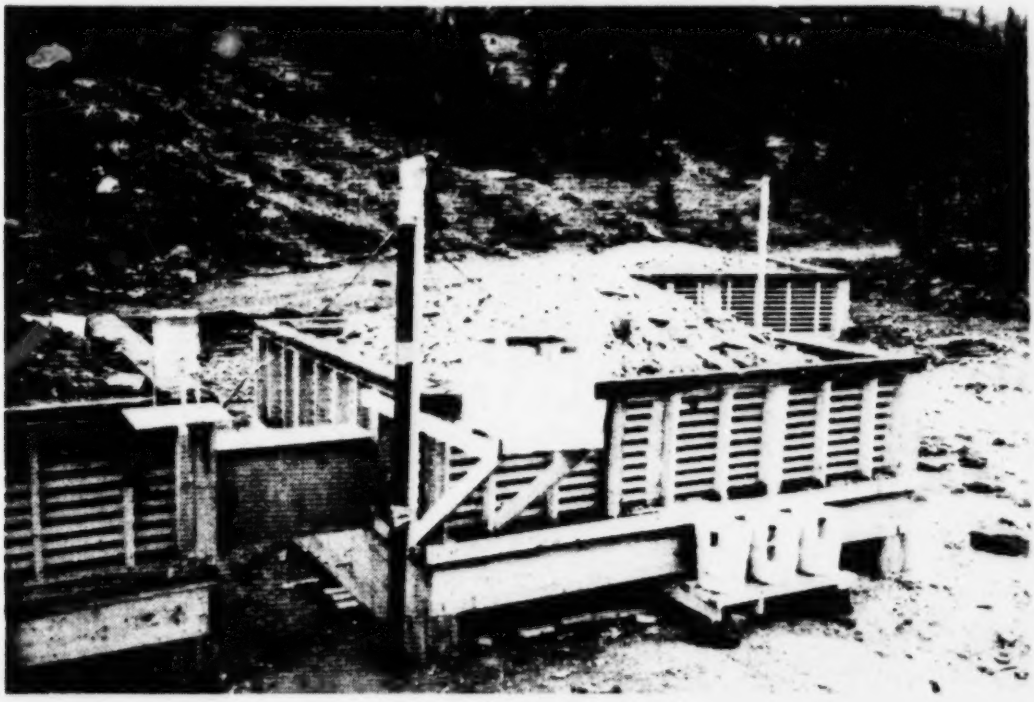


Plate 3-8: A data logger, housed in plywood box, is being used to record rainfall, & temperatures of each pile.

3.2.1 Apparatus and Methodology

The humidity cell apparatus used for Kutcho Creek waste rock testing was designed and assembled according to Rescan specifications. One kilogram sample is placed on a fine mesh plastic screen supported by a perforated acrylic plate inside a circular plexiglass cell having an inside diameter of 100 mm. Air is directed up through the sample via an entrance port on the bottom of the cell, and exits via a port on the top. For soaking the sample, the top lid of the cell is removed and a 500 mL aliquot of water is added which completely submerges the sample. The water is subsequently drained through a port located on the bottom of the cell.

Rock samples were initially jaw crushed to minus 3/8 inch and subsequently cone crushed to minus 1/4 inch mesh until a minimum of 80% (by weight) of the sample passed through a 1/4 inch mesh. One kilogram of the crushed material was then placed in the humidity cell and the lid sealed. For the first 3 days of the 7 day cycle, moist air was blown through the sample. This was followed by 3 days of dry air being blown through the cell. Moist air (100% humidity) is supplied by bubbling air through airstones submerged in a manifold partially filled with water which is maintained at a temperature of 30 C. Dry air at room temperature is achieved by two silica gel column desiccating filters on the air line.

On the 7th day of the testcycle, 500 mL of distilled water is poured into the cell where it completely submerges and soaks the rock sample for a period of 1.0 hour. The leachate is then drained from the cell and filtered through a 0.45 μm filter. It is subsequently analyzed for pH, acidity, alkalinity, sulphate and the following nine metals: aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, and zinc.

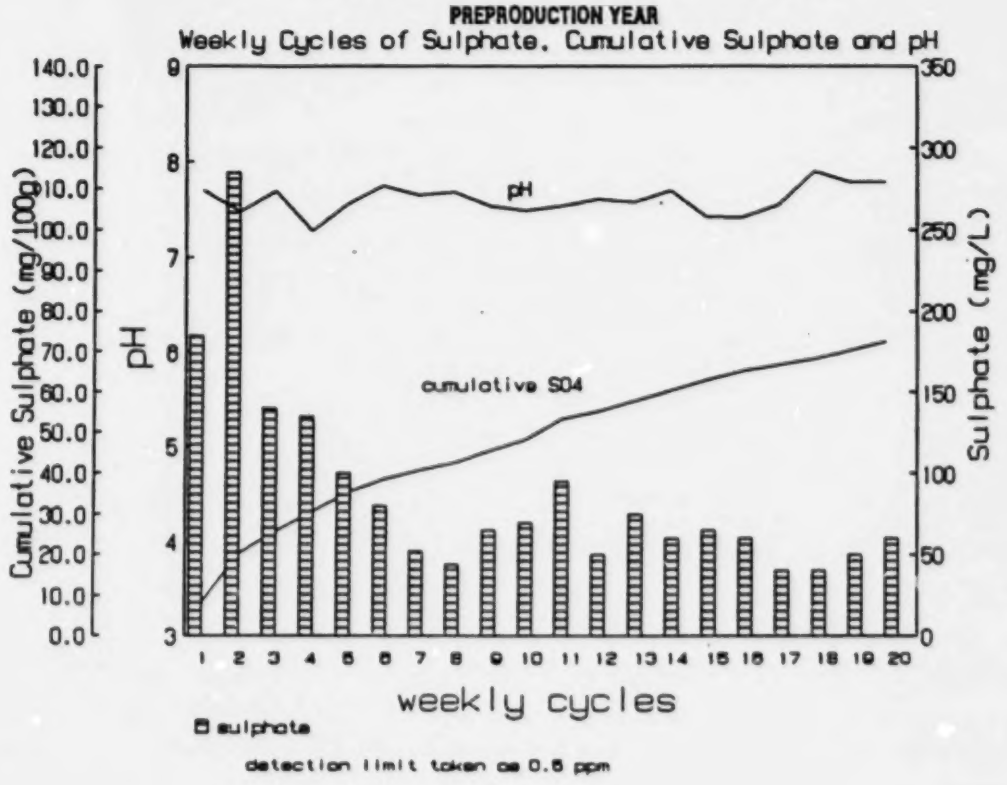
3.3 Test Results

Results for leachate quality during humidity cell testing of Kutcho waste rock samples from the Sumac adit are presented graphically in Figures 3-2 to 3-7.

For the purpose of predicting the effects of blending, the parameters considered were pH, sulphate, cumulative sulphate, and cumulative metals.

KUTCHO CREEK 1990

PREPRODUCTION YEAR



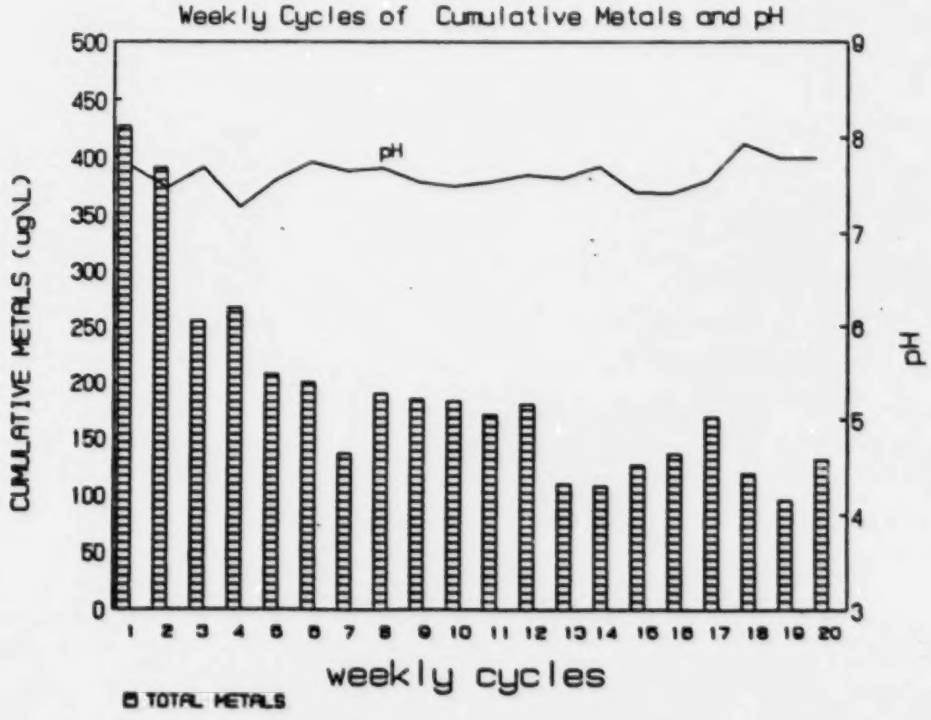
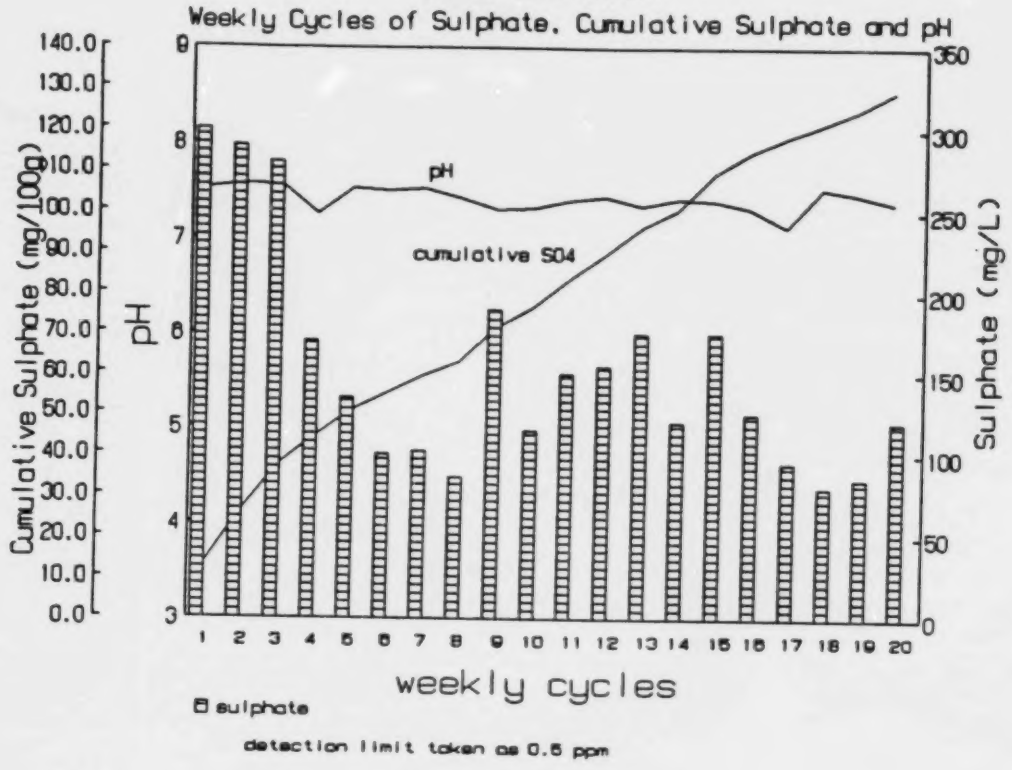


Figure 3-2

Rescan

KUTCHO CREEK 1990

YR-5 (NO SOIL COVER)



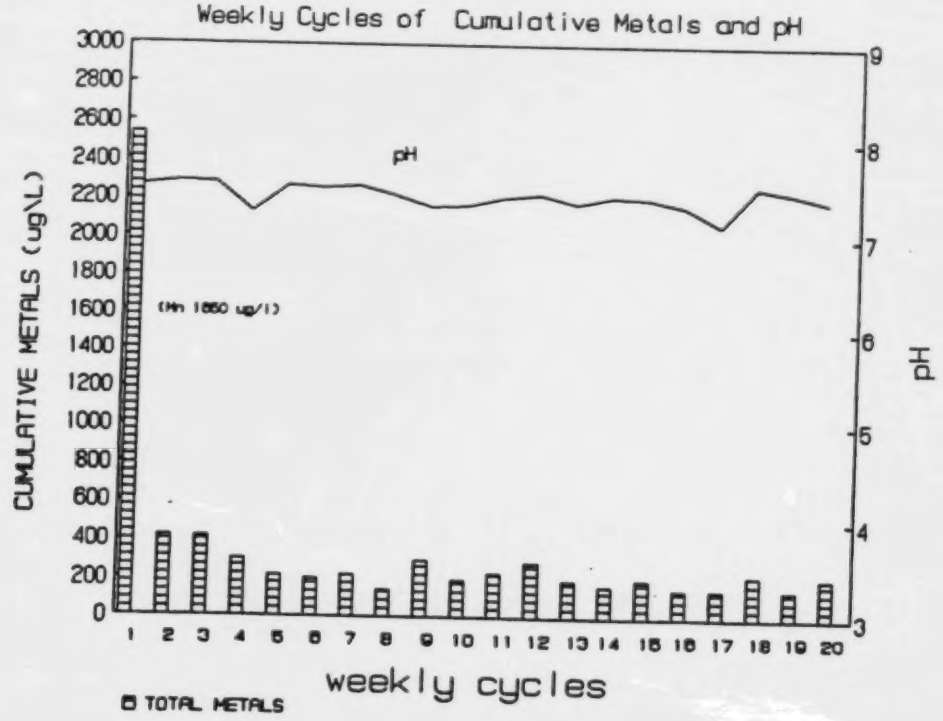
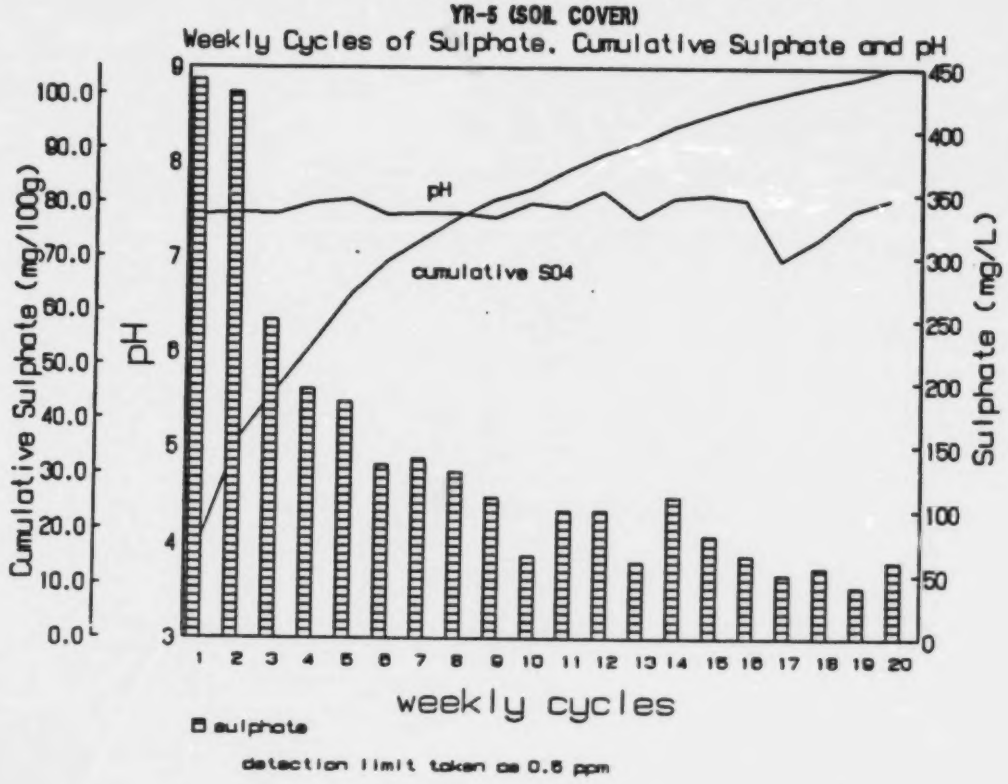


Figure 3-3

Rescan

KUTCHO CREEK 1990

YR-5 (SOIL COVER)



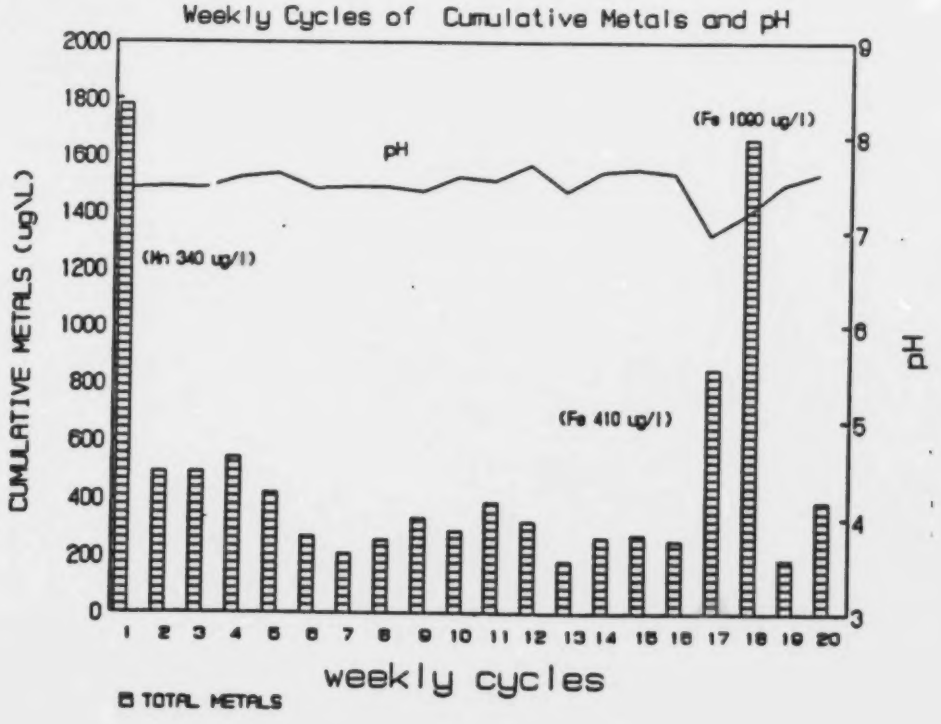
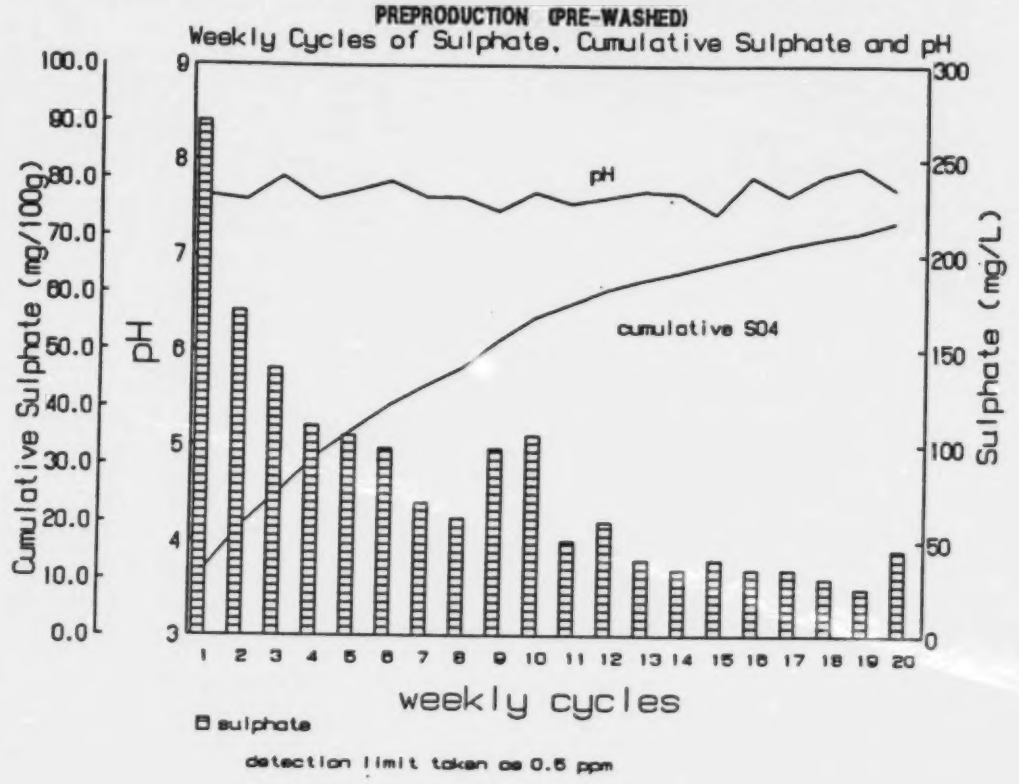


Figure 3-4

KUTCHO CREEK 1990



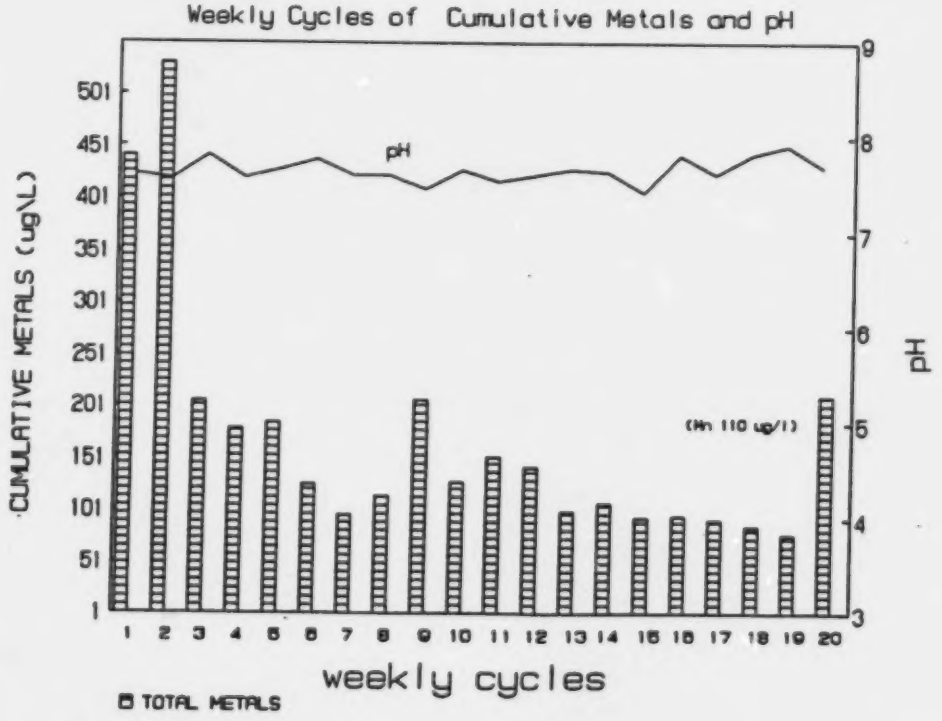
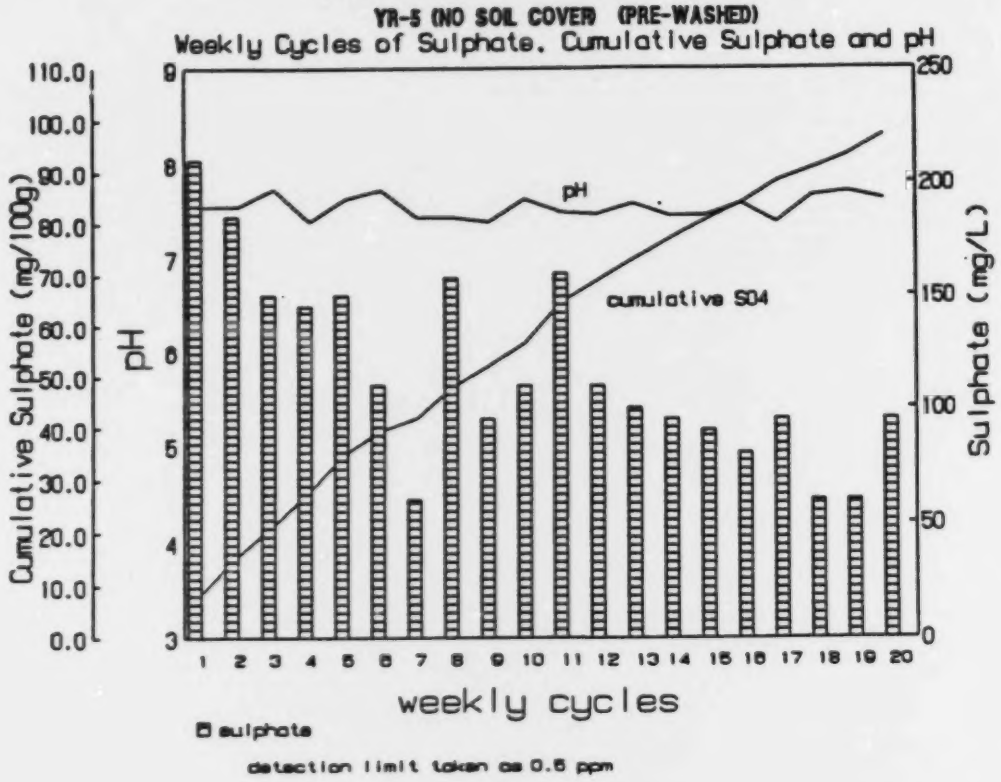


Figure 3-5

Rescan

KUTCHO CREEK 1990

YR-5 (NO SOIL COVER) (PRE-WASHED)



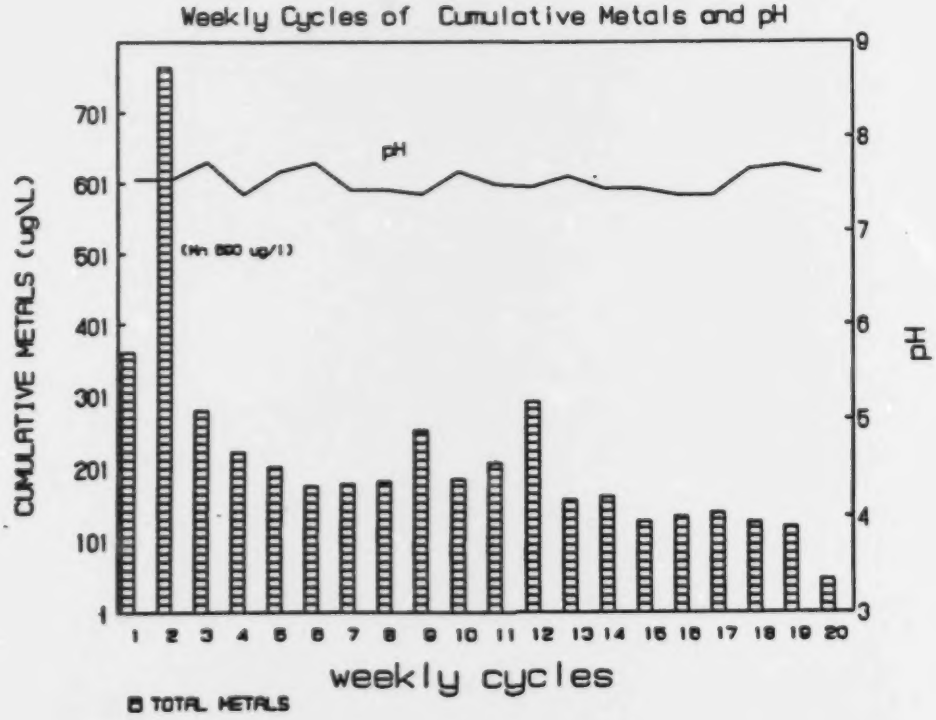
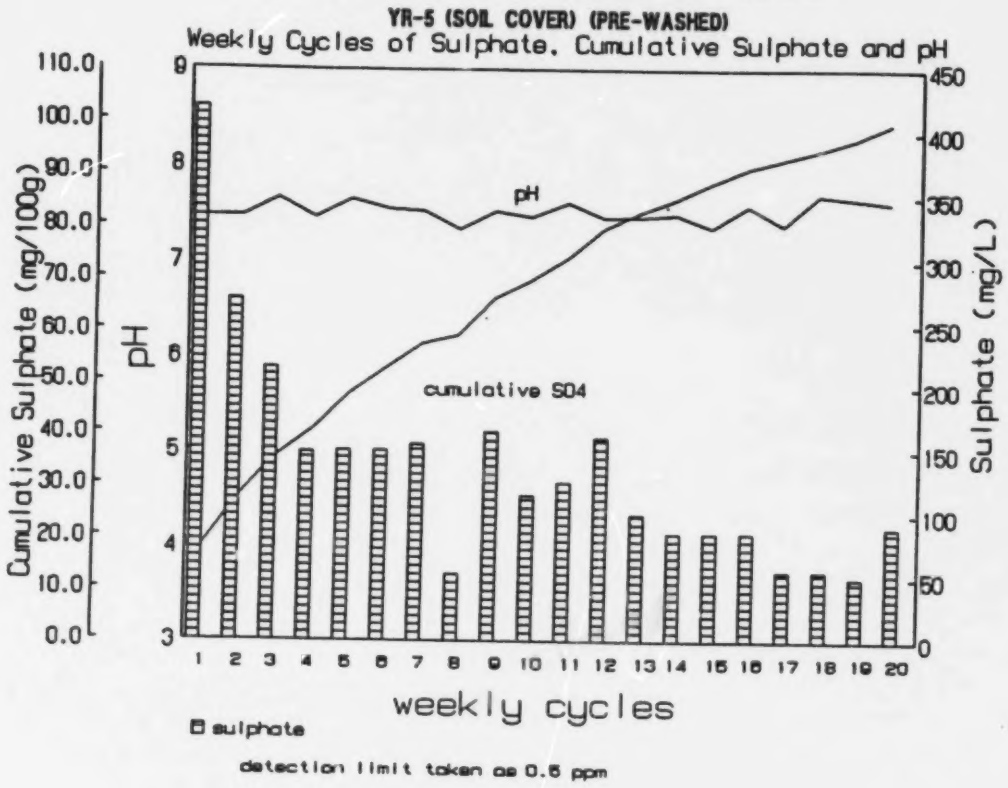


Figure 3-6

Rescan

KUTCHO CREEK 1990



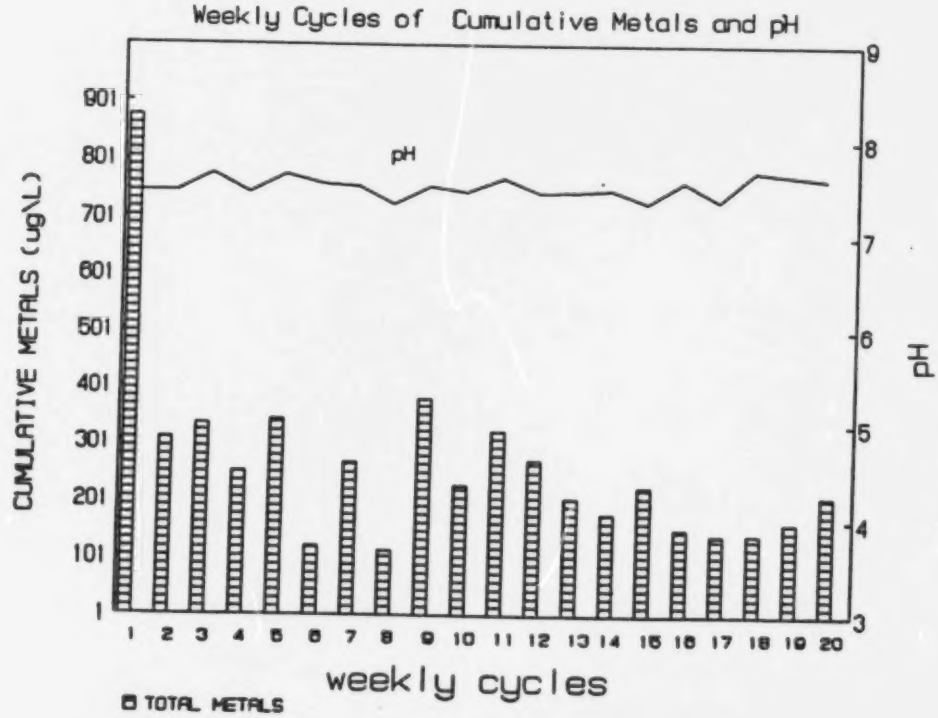


Figure 3-7

Rescan

3.3.1 pH

Weekly pH values give insight to the state of competition between acid-generating and acid-neutralizing reactions in a sample. Leachate from samples did not release appreciable quantities of acid during the entire 20 cycle tests. In fact, the pH of the leachates from all samples remained slightly higher than neutral and displayed a consistent trend of only fluctuating as much as 1 pH unit.

During the 20 week test, a constant pH indicates that acid production was probably offset by neutralizing minerals in the sample.

3.3.2 Sulphate-Sulphur

Sulphate-Sulphur is an oxidation product of acid generation. As such it reflects the weekly rate of acid generation in the humidity cells provided that: sulphate is the only form of sulphur in the sample, and the concentration of sulphate in the leachate is not limited by gypsum which may be precipitated if sufficient quantities of neutralizing calcium carbonate or calcium hydroxide is present in the sample. Consequently, sulphate is generally a better initial indicator of acid production than general parameters such as pH, acidity or metal release.

Constant sulphide oxidation and resulting sulphate release is evident from all cells; albeit at a slow and relatively decreasing rate. Large quantities of sulphate from prior oxidation were released during the first few cycles of humidity cell tests. Unwashed samples tended to release large quantities of sulphate over a longer period of time suggesting that washing had removed at least a portion of prior oxidation products.

Samples (both washed and unwashed) from the 5 year blend with added soil cover indicate less sulphate and a more uniform decrease in sulphate production than the 5 year blend without a soil cover. This suggests that the soil cover may be influencing the rate of oxidation and sulphate release in the laboratory cell.

3.3.3 Metals

Humidity cell testing attempts to achieve a quantitative assessment of acidic drainage and concurrent metal dissolution from mine wastes into the natural environment. Metal concentration in leachates from rock samples undergoing humidity cell testing may vary

as much as an order of magnitude between weekly cycles (i.e. Iron in cycles 17 & 18, Figure 3-5). Without extensive examinations of crystal structures and intensive quality-assurance procedures, the reason for such variations cannot be ascertained. In any case, metal leaching is often most appropriately interpreted by examining the cumulative metal releases over the 20 cycle tests and in observing general trends.

Much like sulphate-sulphur, the resulting cumulative metal release shows a relatively slow and decreasing rate with a few minor fluctuations on a week to week basis. Comparing humidity results of metal dissolution of Stage I to results of Stage II, metal release, over the short term, seems to be minimized in the blended waste rock tests.

The initial flush of metals resulting from prior acid generation is evident from all cells during the first couple of weeks. Washing of the sample did not appear to make a difference with the metals in leachate between the two sets.

A large variation in iron release during cycle 17 and 18 in the 5-year (soil cover) sample is obviously due to a slight decrease in pH. Reasons for the drop are not certain, however because it is such an anomalous occurrence it is probable that a lab procedure is responsible.

4 - Prediction of Acid Generation Rates

Rescan

4.0 PREDICTION OF ACID GENERATION RATES

One of the objectives to the overall study program is to determine the effect and rates of acid generation over short and long term time intervals. The static and kinetic investigations from Phase I and Phase II acid generation testwork provide a basis for predicting the rate of acid generation that is likely to occur in the field.

4.1 Short Term Prediction of Acid Generation for Blended Waste Rock

Kinetic tests from Phase I and Phase II test work provide a basis for comparing acid generation that is likely to occur from blended and non-blended waste rock material.

Non-blended waste rock material is expected to generate more acid than the blended waste rock material due to the relative absence of neutralizing material. Since sulphate is considered a general indicator of acid generation, levels of sulphate that were expected to be produced from each blended cell were calculated from the Phase I test work. Sulphate levels were calculated by averaging the quantity of sulphate released from each rock type that was used in the blended samples (Table 4-1). Expected sulphate levels calculated for the pre-production blend and 5-year blends were 48.2 mg/L and 78.9 mg/L respectively. Actual or observed sulphate production from the Phase II test work was 52.5 mg/L for the pre-production blend and 113.3 mg/L for the 5-year blends. It would appear that over the short term, acid generation rates were not significantly reduced in blended waste rock material as shown by actual sulphate produced. However, the pH remained relatively constant fluctuating near neutral.

Calculations for expected total metal release were calculated using total metal values from the Phase I testwork. Expected total metal values for pre-production blends were 4.90 mg/L and in the 5-year blends 9.69 mg/L. Observed total metal release for pre-production and 5-year blends were 0.13 mg/L and 0.60 mg/L respectively. Comparison of predicted and actual metal release show that metal solubility has been effectively reduced in leachate of blended tests from 94% in 5-year blends to 98% in the pre-production blend.

In general, the short term acid generation rates for blended rocks show that the rate of acid generation was not significantly reduced in the blended samples as was expected

Table 4-1

Calculation Table for Determining Expected Sulphate and Cumulative Metal Release

Rock Type	Sample # (Phase I)			Ratio of Blend			Expected Value mg/L
Pre-Production Year (Blended Ratio Pyritic 1:6 Non-pyritic)							
I. Sulphate		Average* Sulphate mg/L					
QFXT	KA6 to 11	6.8	x	1.0	=	6.8	
XLT	KA12 to 13	2.0	x	1.0	=	2.0	
ASHT	KA14	35.0	x	1.0	=	35.0	
SQLT (PY)	KA22	250.0	x	0.5	=	125	
						168.8 ÷ 3.5	48.2
II. Cumulative Metals		Total Metals* mg/L					
QFXT	As Above	0.18	x	1.0	=	0.18	
XLT		0.10	x	1.0	=	0.10	
ASHT		0.07	x	1.0	=	0.07	
SQLT (PY)		33.61	x	0.5	=	16.80	
						17.16 ÷ 3.5	4.9

Table 4-1 (cont'd)

Rock Type	Sample # (Phase I)			Ratio of Blend			Expected Value mg/L
5 Year Blend (Blended Ratio Pyritic 1:2.5 Non-pyritic)							
I. Sulphate		Average* Sulphate mg/L					
QFXT	KA6 to 11	6.8	x	1.0	=	6.8	
XLT	KA12 to 13	2.0	x	1.0	=	2.0	
ASHT	KA 14	35.0	x	0.5	=	17.5	
SQLT (PY)	KA22	250.0	x	1.0	=	250.0	
						276.3 ÷ 3.5	78.9
II. Cumulative Metals		Total Metals* mg/L					
QFXT	As Above	0.18	x	1.0	=	0.18	
XLT		0.10	x	1.0	=	0.10	
ASHT		0.06	x	0.5	=	0.03	
SQLT (PY)		33.61	x	1.0	=	33.61	
						33.92 ÷ 3.5	9.69

QFXT = Quartz Feldspar Crystal Tuff
XLT = Crystal Lapilli Tuff
ASHT = Mafic Ash Tuff
SQLT (PY) = Sericite Quartz Lapilli Tuff (Pyritic)
* = Numbers based on Phase I, Humidity Cell Testwork

however, the rate of neutralization is sufficient to maintain a slightly alkaline pH, thus drastically reducing metal leaching in both pre production and 5 year blends.

4.2 Long Term Prediction of Acid Generation for Blended Waste Rock

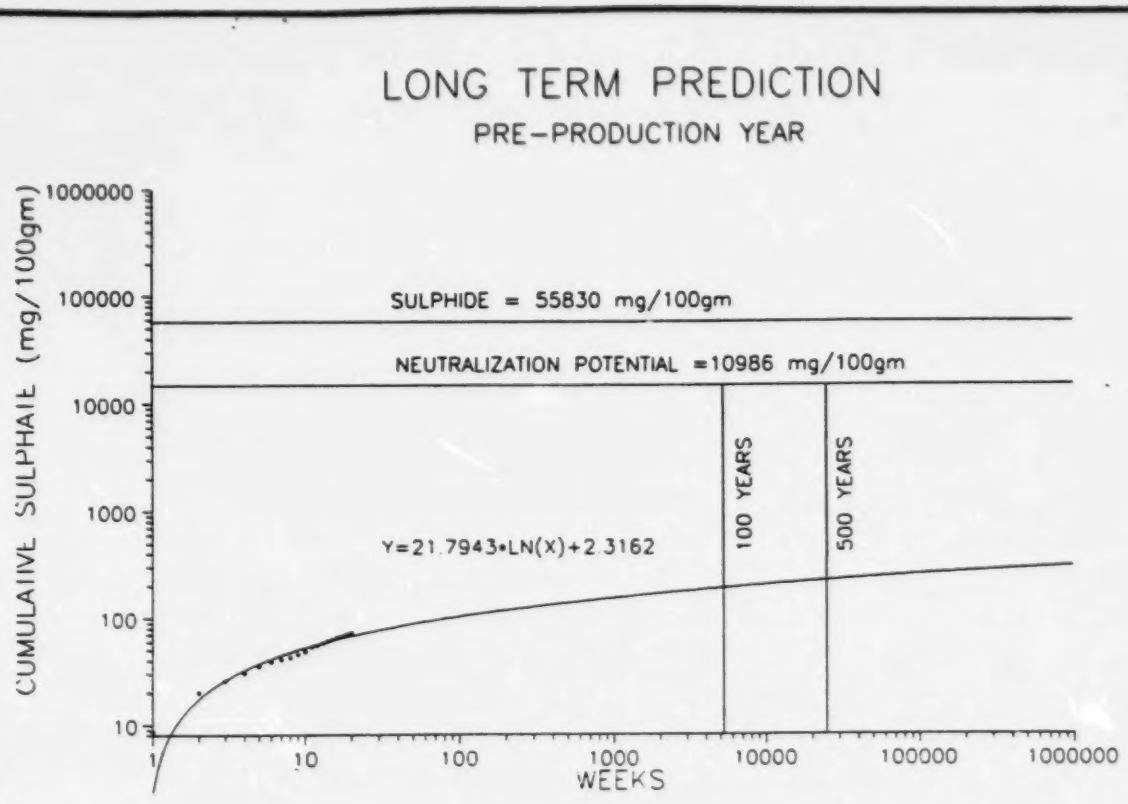
The best available information for predicting long term acid generation for the Kutcho project is the data from the blended samples tested in humidity cells and acid base accounting of rock lithologies. Kinetic experiments in this study were carried out for a period of 20 weeks. Long term acid generation rates were predicted using a relatively simple mathematical expression that describes a best-fit extrapolation of data. This procedure assumes that all acid consuming components are available, and that all sulphide minerals are reactive not taking into account mineralogy, crystal habit or surface area exposed.

As discussed in section 3.3.2, the general acid generation trend observed in humidity cell experiments for the Kutcho project was that acid generation was occurring albeit at a slow and relatively decreasing rate. In theory, the rate will continue to decrease indefinitely and the cumulative sulphate trend will level out over time. This trend is observed in the pre-production and 5-year (with soil cover) blends as shown in Figures 4-1 and 4-2.

Acid generation rates, as indicated by sulphate production show a decrease over time. The extrapolation curve indicates that acid generation will not exceed the neutralization potential of the blend. This would imply that blended samples contain sufficient carbonate materials to neutralize the generated acidity and that the pH of the flush water will remain neutral or alkaline.

In theory, acid generation cannot proceed indefinitely because all available sulphide minerals in the blended sample will eventually be consumed. However, extrapolation of data indicates that total sulphides will never be completely consumed and that acid generation will continue indefinitely over time.

It would be difficult to conclude, based on these few laboratory results, whether or not the soil cover is responsible for the decrease in acid generation in the 5-year blends. As shown in Figure 4-3, acid generation appears to continue at a relatively constant rate for the uncovered waste material. Extrapolation of the rate curve shows that acid generation and subsequent neutralization will consume all the neutralization potential



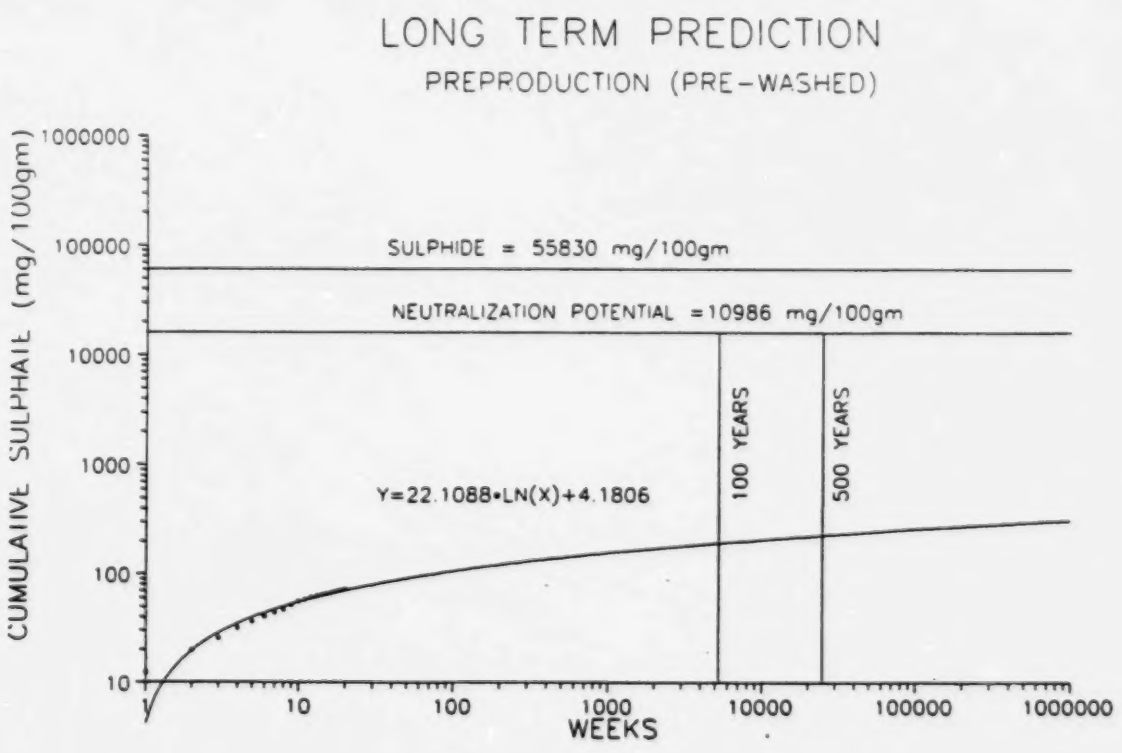
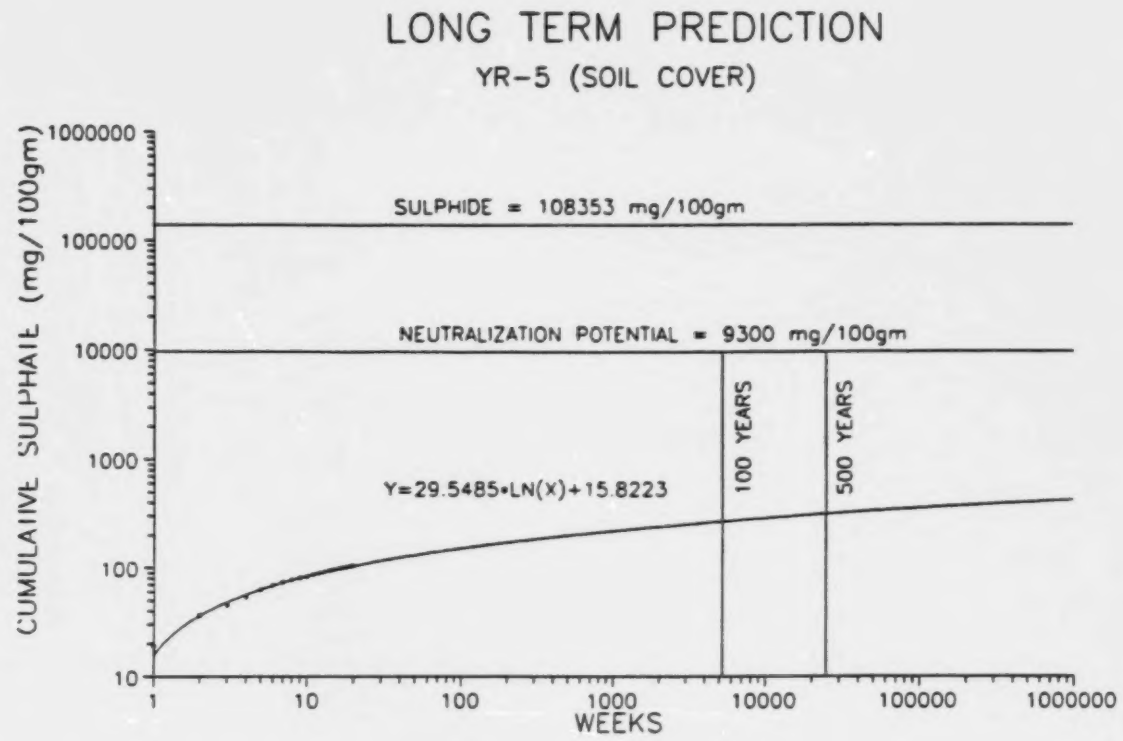


Figure 4-1

DB-R0022



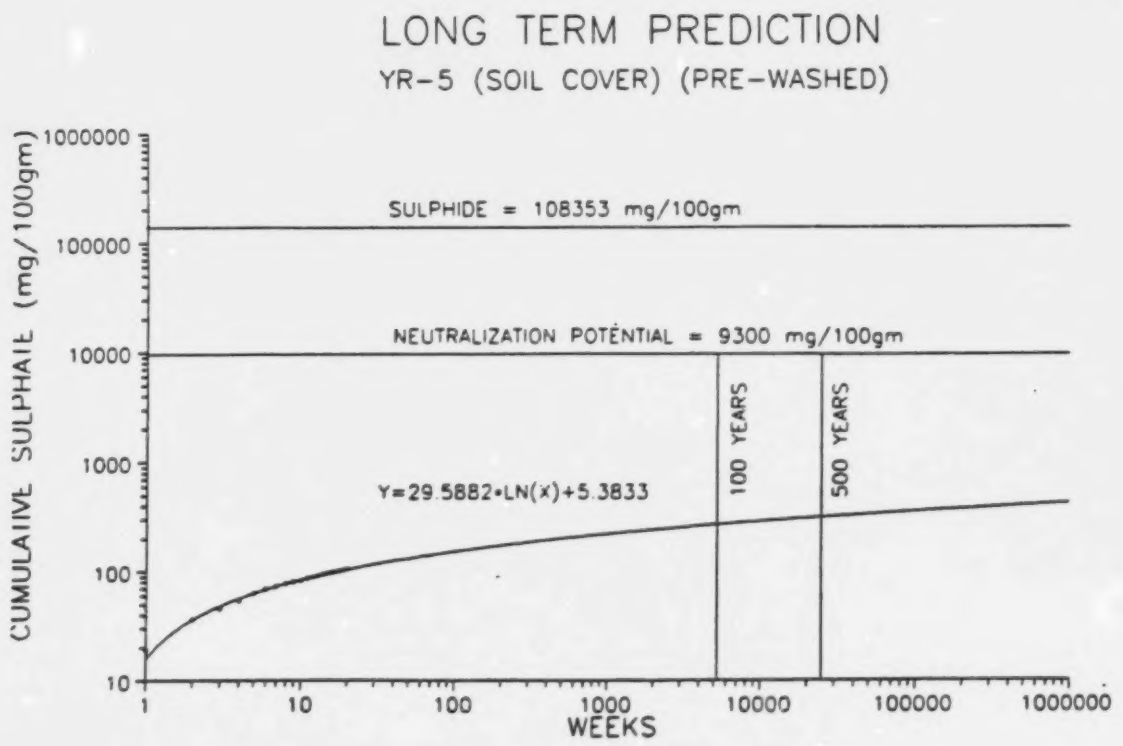
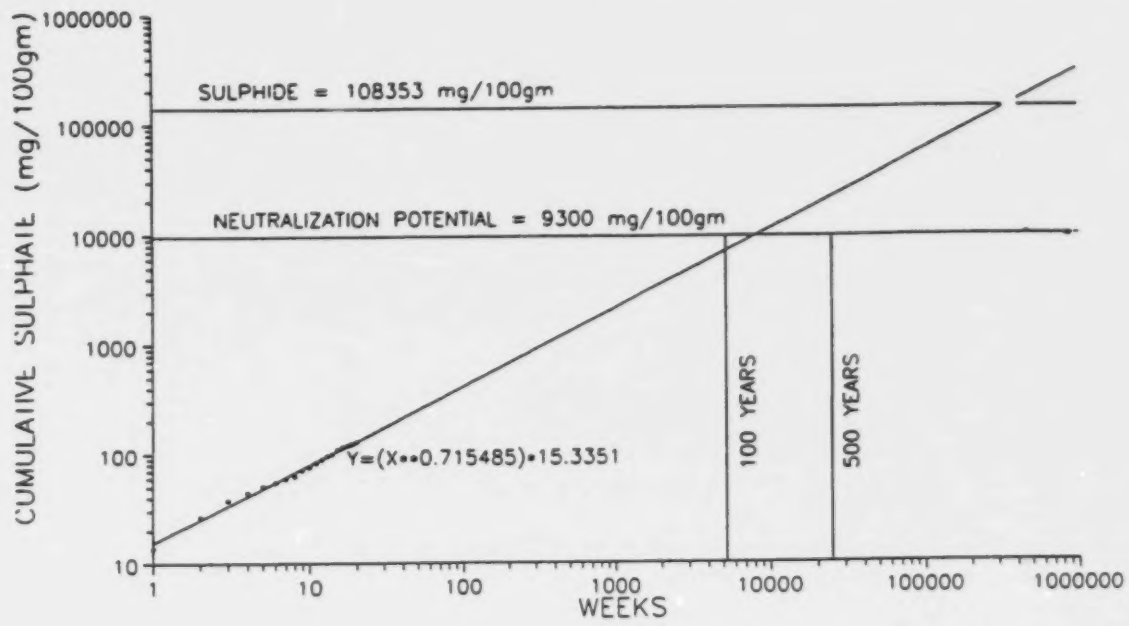


Figure 4-2

DB-R0022



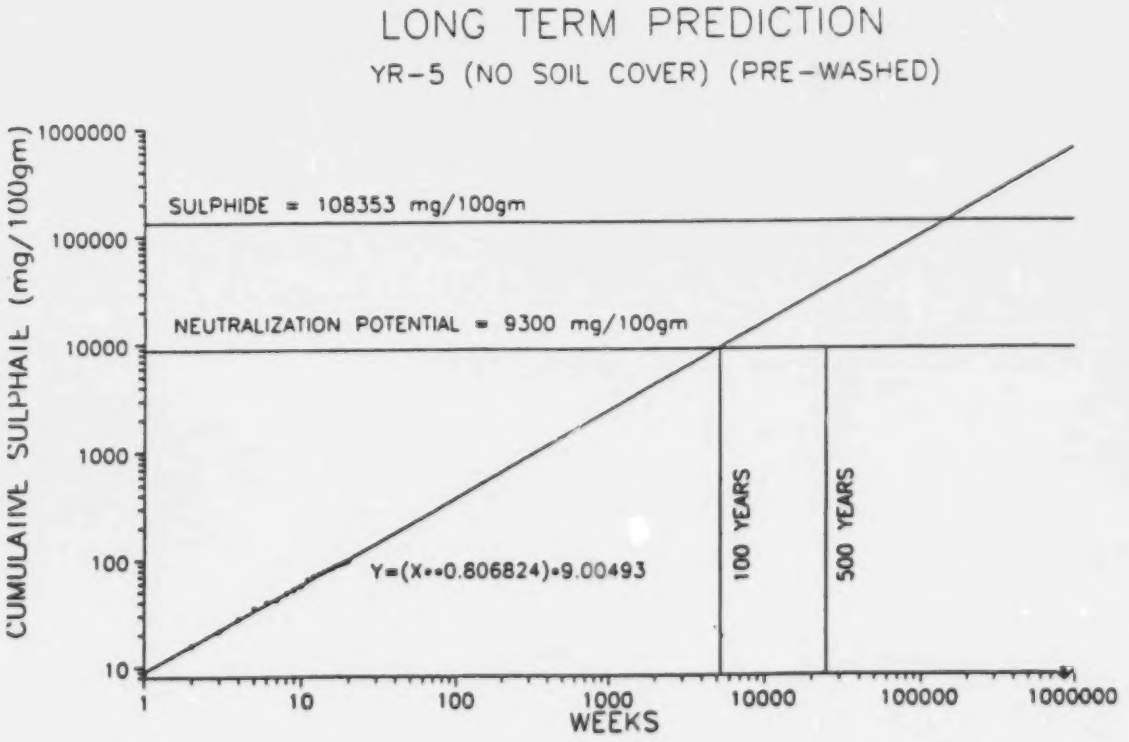


Figure 4-3

DB-R0022

of the sample within 100 years (week 5200) and will continue until all sulphide material is eventually consumed in 3,000 years (week 160,000). It would be safe to predict that in the 5-year blends, acid generation will not decrease, and that the neutralization potential will not be sufficient to keep the associated waters neutral.

In summary, these results indicate that, samples mixed with the pre-production ratio of 1:6 pyritic to non-pyritic waste material will provide sufficient neutralization of associated waters to eliminate acid rock drainage. Waste piles designed with the 5-year blend (1:2.5) will produce net acid drainage when the carbonate components are consumed.

5 - Conclusions and Further Studies

5.0 CONCLUSIONS AND FURTHER STUDIES

The acid generation test program for Kutcho Creek waste rock is currently entering its third year. Phase I humidity cell testing, and petrographic examinations of the footwall pyritic tuff have indicated that sulphides in the footwall waste rock oxidize rapidly and are potentially acid generating whereas hanging wall rock is potentially acid consuming. Phase II testwork involved the construction and implementation of twenty-tonne field test plots to examine whether blending acid generating pyritic footwall wastes with acid consuming hanging wall wastes will prevent acid drainage in full scale waste dumps. Preliminary results are not yet available since these field plots were constructed in late September 1989, just prior to winter freeze-up.

The large field test plots were complimented by running a set of laboratory humidity cell tests parallel in rocktype and ratio. These tests demonstrated that over the short term acid generation was not significantly reduced, however, the rate of neutralization remains constant enough to maintain an elevated pH such that metal solubilization is drastically reduced. Over the long term, pre-production blends of pyritic vs. non-pyritic waste rock (1:6) will continue to produce acid but will be effectively neutralized by carbonate materials in the waste pile. Blends of the 5-year ratio (1:2.5) will also continue to produce acid but at a higher rate and will eventually consume the carbonate components of the waste pile and continue to produce an acid drainage in the long term.

Acid-base accounting tests were also run on select sections of core from the Kutcho project area. Analysis of the sulphur form indicated that most sulphur in the rock exists as sulphide, and that potential acid generating units are controlled by lithology and not by depth or spatial distribution. Based on the relative proportions of acid consuming and acid generating materials, the potential exists for acid drainage through the excess of acid producing materials on site. Results from the humidity cell testwork show that in order to achieve a blended waste pile to control acid generation, the ratio of acid generating to acid consuming materials should be at least 1:6. Therefore, field blending of waste rock would not be viable because of insufficient acid consuming materials on site. A combination of measures will have to be considered in order to achieve the most beneficial and cost effective means to control acid generation.

One viable strategy, for example, may include flooding the open pit upon abandonment. Subaqueous disposal is known to preclude acid generation from sulphidic wastes since it prevents their exposure to oxygen and bacterial action. Flooding of the open pit will not only provide a disposal area for acid generating wastes, but will provide a means of controlling acid generation from the exposed rock faces. However, because Kutcho will be a single pit operation, it will be necessary to store the reactive waste rock produced during the life of the mine until it can be moved back into the open pit upon closure.

Two short term options are available, of which both require a suitable stockpile facility built with a confining dyke and catchment pond area. One option is to blend waste materials with limestone to help neutralize acid waters generated. The second option is to cover or seal the waste stockpiles to try and restrict the access of oxygen and water to the reactive mine wastes. Restricting water movement will serve to limit both the formation of acid and subsequent transport of oxidation products into the environment.

A major effort in Phase III will be to monitor the water quality and to integrate the data obtained from the instruments installed in the small-scale test dumps. The water quality monitoring should be done monthly on a composite sample for a period of six months, starting with the freshet in May and continuing until freeze-up in late October. As well, pH probes to continuously monitor the discharge from each test dump and an additional probe to monitor the pH of rainfall will be installed. pH will be compared directly with the drainage from the experimental dump, rainfall, internal and external temperature, and oxygen concentrations within the dumps.

The Phase III field study will provide a good comparison of small-scale field program to bench scale humidity test results. The information generated during the Phase III field program will complete this Kutcho Creek study program. When finished, the Kutcho Creek research study will provide field evidence on the viability of blending acid generating and acid consuming waste rock as a means of controlling acid generation emanating from large scale waste rock dumps. Potential reclamation strategies for mine closure could also be more rigorously evaluated given a more thorough understanding of the acid generation potential of the footwall waste this study will provide.

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Miscellaneous maps from Esso and Sumac outlining plan distribution and cross-section lithology from sections 2540E to 3200E (Sumac maps) and 37640E to 38520E (Esso maps)

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APPENDIX A

ACID BASE ACCOUNTING
(ANALYSIS AND PROCEDURES)

Rescan

DB-80055

Summary of Acid Base Accounting

ROCK TYPE	AVG. DEPTH (m.)	INTERVAL (m)	TOTAL S% (Leco)	MAX. POT. ACID **	NEUT. POT. **	NET NEUT. POT.	PASTE pH	CO2 %	SULPHATE S%	SULPHIDE S%***	SAMPLE NUMBER
GABBRO	2.7	0.6	0.229	7	300	293	8.5	12.6	0.01	0.12	43
	17.6	0.5	0	0	206	206	9.2	9.2	0.01	0	9
	54.6	0.6	0	0	159	159	8.7	7.7	0	0	25
	20.7	0.6	0.073	2	128	126	9.5	4	0	0	13
	14	0.6	0.155	5	99	94	9.1	2.5	0.03	0.08	29
	64.9	0.6	0.06	2	201	199	8.9	8.6	0.02	0	34
	11.2	0.7	0.548	17	218	201	8.7	11.2	0.01	0.39	40
QUARTZ	100	0.6	0	0	53	53	9	1.9	0	0	26
CRYSTAL	82.6	0.6	0.085	3	141	138	8.8	6.7	0	0	30
TUFF	47.2	0.6	0.037	1	45	44	9.4	1.7	0	0	10
BRECCIA	23.2	0.6	0.125	4	42	38	9.3	1.7	0	0.02	22
	13.2	0.9	0.186	6	51	45	9.1	1.6	0.01	0.04	18
QUARTZ	58.3	0.9	0.125	4	281	277	8.5	12.3	0	0	41
FELD.	60.3	0.6	0.001	0	57	57	9.5	2.7	0	0	23
CRYSTAL	143.2	0.6	0.025	0	139	139	9.2	5.9	0	0	35
TUFF	59.7	0.6	0.094	3	41	38	9.6	1.5	0	0	14
	44.5	0.6	0.036	1	30	29	8.9	2.5	0.01	0	6
	37.2	0.6	0	0	182	182	8.9	9.5	0.02	0	19
	27.4	0.7	0	0	72	72	9.1	3.7	0	0	1
	9.1	0.6	0.426	13	566	553	9.4	27.9	0.02	0.36	47
	46	0.6	0.1	3	38	35	9.2	1.7	0.01	0	49
	112.1	0.7	0.019	0	94	94	8.9	4.9	0	0	15
	58.7	0.5	16.5	516	3	-513	5.7		0.03	17.01	3
	30.1	0.5	1.81	57	129	72	8.5	5.9	0.01	1.57	44
	93.2	0.7	0.053	2	40	38	9.3	1.9	0	0.01	11
	160.6	0.6	0.813	25	97	72	9	4.9	0	0.7	36
	51.4	0.8	0	0	47	47	9.1	1.9	0	0	2
ASH	135.9	0.6	0.98	31	109	78	9	5.1	0	0.89	16
TUFF	136.9	0.9	6.84	214	278	64	8.4	14.9	0.01	6.94	12
	131.1	0.6	0	0	189	189	9.4	9.8	0	0	27
	132.2	0.7	0.038	1	422	421	8.7	20.4	0	0	31
	64.9	0.6	5.33	167	22	-145	7.4	0.7	0.02	5.34	21
	77.7	0.6	0.186	6	140	134	9.4	7.8	0	0.05	24
	48.2	0.6	0.289	9	183	174	8.8	10	0	0.19	20
	90.8	0.6	0.177	6	121	115	9.3	6.1	0	0	7
MASSIVE	169.2	0.9	7.53	235	8	-227	7.7	0.4	0.02	8.04	32
SULPHIDES	119.2	1.2	26.3	822	2	-820	6.5		0.09	26.73	42
	28.3	1.2	17.2	538	60	-478	8.1		0.02	16.08	48
	66.1	0.6	0.069	2	311	309	8.4	15	0	0	45
	167	0.6	2.53	79	181	102	9	8.3	0.01	2.36	37
	108.5	0.6	4.08	128	44	-84	8.2	1.6	0.02	3.73	8
	32	0.6	34.9	1090	60	-1030	6.9		0.03	35.87	4
	110.1	1.5	46.9	1470	85	-1385	7		0.07	46.74	50
QUARTZ	78.1	0.9	36.2	1130	181	-949	8		0.07	37.31	46
SERICITE	46.3	0.6	2	63	117	54	8.6	1	0	1.97	5
LAPILLI	180	1.5	10.9	341	1	-340	6.3		0.03	11.51	28
TUFF	197.8	0.6	31.9	997	42	-955	6.9	8.6	0.08	33.41	39
	190.9	0.9	7.84	245	2	-243	7.3	0.3	0.02	7.97	33
	192	1.2	11.2	350	77	-273	8.2	4.6	0.03	11.74	38
	185.3	0.6	19.5	609	1	-608	5.7		0.04	20.14	17

Analysis by Chemex Laboratories, Vancouver, B.C.

Chemex Labs Ltd.

Analytical Chemists *Geochemists* *Registered Assayers*

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Acid Base Accounting Procedures

1. Paste pH

Soil pH is measured by a glass electrode incorporated with a pH meter for this procedure. Water is added to the sample forming a paste. The electrode is placed in the paste with pH being read directly from the meter.

2. Neutralization Potential

Principles -

The amount of neutralizing bases, including carbonates, present in over- burden materials is found by treating a sample with a known excess of standardized hydrochloric acid. The sample and acid are heated to insure that the reaction between the acid and the neutralizers goes to completion.

The calcium carbonate equivalent of the sample is obtained by determining the amount of unconsumed acid by titration with standardized sodium hydroxide (Jackson, 1958).

3. Maximum Potential Acidity by Total Sulfur Determination

This method measures the total sulfur in a sample. If all of the total sulfur occurs in pyritic forms, the calculation of maximum potential acidity from sulfur corresponds with actual potential acidity from sulfur. But if part of the sulfur occurs in other forms, the maximum as calculated will be too high. This is the reason that such calculations are referred to as maximums and in doubtful cases approximate determinations should be made which rule out other sulfur forms. These determinations are not necessary when the maximum acid from total sulfur is within safe limits.

A sample is heated to approximately 1600 C. A stream of oxygen is passed through the sample during a heating period. Sulfur dioxide is released from the sample and collected in a dilute hydrochloric acid solution containing potassium iodide, starch and a small amount of potassium iodate. This solution is automatically titrated with a standard potassium iodate solution. The CS-125 Leco Analyzer uses an IR detection system.

APPENDIX B

HUMIDITY CELL TESTWORK AND METAL ANALYSIS

Rescan

Humidity Cell Metal Analyses - Yr-5 (soil cover)

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
YR-5(C)	1	2.5	2.6	2.3	110	79	2	1340	0.34	240	7.45	440	19
5026-1	2	10	1.6	0.6	26	7.5	2	430	0.1	13	7.47	430	36.5
	3	19	3.2	0.3	32	32	2	350	0.18	53	7.46	250	45.5
	4	57	40	0.2	49	110	3	200	0.18	83	7.57	195	54
	5	40	0.9	0.1	39	7.5	6	310	0.08	18	7.61	185	63
	6	8	2	0.1	11	7.5	0.5	230	0.08	11	7.45	135	69.3
	7	7	0.8	0.1	1	7.5	0.5	180	0.025	10	7.47	140	73.5
	8	30	2.5	0.2	49	50	6	99	0.45	20	7.47	130	77.5
	9	18	4	0.3	70	7.5	3	140	0.78	90	7.42	110	80.7
	10	60	2.7	0.1	51	63	8	79	0.54	23	7.57	65	82.6
	11	26	2.3	0.1	24	65	120	130	0.12	17	7.53	100	86.2
	12	37	3.2	0.1	49	82	7	120	0.82	20	7.7	100	89.1
	13	21	2.9	0.1	20	41	2	82	0.07	13	7.42	60	91.3
	14	16	2	0.1	54	47	0.5	120	0.18	25	7.63	110	94.2
	15	26	1.7	0.1	55	84	6	83	0.29	19	7.46	80	96.5
	16	35	3.1	0.2	51	45	7	80	0.24	30	7.61	65	98.5
	17	36	2.1	0.6	35	410	4	170	0.2	190	6.97	50	100.2
	18	47	1.9	0.7	41	1090	7	170	0.28	300	7.19	55	101.8
	19	22	3.9	0.1	45	38	0.5	74	0.13	2.5	7.49	40	103.1
	20	100	1.8	0.2	41	120	2	92	0.11	31	7.61	60	104.9

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with "Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Yr-5 (soil cover)

RESCAN Kutcho Creek SAMPLE 5026 - 1

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.431	7.45	1445	24.0	0.0	10.8	0.5	440	19.0
2	14	0.407	7.47	1103	18.1	0.0	10.8	0.9	430	36.5
3	21	0.362	7.46	628	18.6	0.0	20.2	1.6	250	45.5
4	28	0.437	7.57	368	23.5	0.0	5.2	1.9	195	54.0
5	35	0.482	7.61	355	24.5	0.0	6.1	2.1	185	63.0
6	42	0.467	7.45	375	16.3	0.0	2.8	2.3	135	69.3
7	49	0.305	7.47	338	15.7	0.0	23.5	3.0	140	73.5
8	56	0.307	7.47	301	16.7	0.0	6.2	3.2	130	77.5
9	63	0.285	7.42	266	23.8	0.0	3.5	3.3	110	80.7
10	70	0.299	7.57	248	20.0	0.0	3.3	3.4	65	82.6
11	77	0.358	7.53	324	16.4	0.0	3.3	3.5	100	86.2
12	84	0.292	7.70	284	23.3	0.0	2.5	3.6	100	89.1
13	91	0.359	7.42	174	14.0	0.0	2.6	3.7	60	91.3
14	98	0.267	7.63	277	19.5	0.0	1.7	3.7	110	94.2
15	105	0.290	7.46	222	19.1	0.0	1.2	3.7	80	96.5
16	112	0.312	7.61	192	20.7	0.0	1.7	3.8	65	98.5
17	119	0.323	6.97	157	18.1	0.0	2.4	3.9	50	100.2
18	126	0.305	7.19	160	15.0	0.0	2.9	4.0	55	101.8
19	133	0.311	7.49	156	17.5	0.0	1.9	4.0	40	103.1
20	140	0.300	7.61	197	20.2	0.0	2.2	4.1	60	104.9

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.

Humidity Cell Metal Analyses - Yr-5 (no cover)

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
YR-5(UC)	1	2.5	0.2	5.5	13	85	0.5	1650	0.85	780	7.53	300	13.7
5026-2	2	18	0.5	0.4	3	7.5	1	380	0.025	7	7.57	290	26.4
	3	19	0.8	0.4	0.5	7.5	0.5	360	0.025	25	7.56	280	37.6
	4	25	3.8	0.3	3	7.5	0.5	240	0.025	17	7.26	170	44.5
	5	43	1.6	0.2	2	7.5	0.5	150	0.025	7	7.53	135	50.8
	6	9	0.4	0.1	0.5	7.5	0.5	160	0.05	17	7.51	100	55.1
	7	11	2	0.1	12	7.5	5	160	0.22	18	7.53	102	59.6
	8	17	0.4	0.1	3	7.5	1	110	0.07	2.5	7.44	86	63.1
	9	11	0.3	0.2	3	7.5	1	170	0.025	100	7.32	190	71.6
	10	54	0.8	0.1	3	7.5	2	110	0.025	14	7.33	115	76.6
	11	50	0.5	0.1	3	30	8	130	0.05	8	7.41	150	83.4
	12	39	0.7	0.1	3	25	2	200	0.05	16	7.45	155	89.6
	13	8	0.9	0.3	3	7.5	0.5	160	0.025	14	7.36	175	96.2
	14	2.5	0.4	0.1	3	7.5	0.5	150	0.025	2.5	7.43	120	100.8
	15	12	0.2	0.1	4	17	0.5	140	0.025	21	7.41	175	109.4
	16	16	0.2	0.2	2	7.5	2	110	0.025	11	7.33	125	114.6
	17	13	0.4	0.1	3	7.5	0.5	110	0.025	16	7.13	95	118.4
	18	11	0.4	0.1	4	53	1	110	0.025	39	7.54	80	121.6
	19	5	0.6	0.1	2	7.5	0.5	120	0.025	14	7.48	85	124.9
	20	12	0.2	0.1	4	20	0.5	150	0.025	21	7.39	120	129.5

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with."Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Yr-5 (no cover)

RESCAN Kutcho Creek SAMPLE 5026 - 2

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.458	7.53	721	21.0	0.0	13.9	0.6	300	13.7
2	14	0.435	7.57	744	16.7	0.0	14.6	1.3	290	26.4
3	21	0.401	7.56	633	18.1	0.0	27.7	2.4	280	37.6
4	28	0.405	7.26	526	13.3	0.0	3.3	2.5	170	44.5
5	35	0.467	7.53	372	20.4	0.0	10.8	3.0	135	50.8
6	42	0.430	7.51	266	20.4	0.0	3.8	3.2	100	55.1
7	49	0.445	7.53	332	17.2	0.0	3.8	3.4	102	59.6
8	56	0.410	7.44	271	13.7	0.0	6.7	3.6	86	63.1
9	63	0.447	7.32	410	13.2	0.0	2.6	3.7	190	71.6
10	70	0.436	7.33	345	12.5	0.0	4.3	3.9	115	76.6
11	77	0.448	7.41	377	12.7	0.0	3.0	4.1	150	83.4
12	84	0.400	7.45	397	21.7	0.0	1.3	4.1	155	89.6
13	91	0.377	7.36	386	10.5	0.0	2.0	4.2	175	96.2
14	98	0.390	7.43	274	11.5	0.0	1.7	4.3	120	100.8
15	105	0.489	7.41	416	11.3	0.0	1.0	4.3	175	109.4
16	112	0.419	7.33	299	13.3	0.0	1.5	4.4	125	114.6
17	119	0.398	7.13	269	12.7	0.0	1.7	4.4	95	118.4
18	126	0.392	7.54	230	12.8	0.0	1.1	4.5	80	121.6
19	133	0.398	7.48	265	12.9	0.0	1.9	4.6	85	124.9
20	140	0.379	7.39	296	13.8	0.0	1.6	4.6	120	129.5

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.

Humidity Cell Metal Analyses - Preproduction

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
PPD(UW)	1	31	0.4	0.3	0.5	7.5	0.5	360	0.025	27	7.7	185	185
5026-3	2	23	1.3	0.1	1	7.5	0.5	350	0.025	7	7.48	285	20.1
	3	30	0.7	0.1	2	7.5	0.5	180	0.1	34	7.69	140	25.8
	4	54	3.3	0.1	3	7.5	2	130	0.025	67	7.28	135	30.5
	5	100	2.8	0.1	2	7.5	0.5	92	0.025	2.5	7.56	100	35.5
	6	22	0.6	0.1	4	7.5	0.5	150	0.025	15	7.75	80	38.6
	7	18	1.5	0.1	2	7.5	1	100	0.12	6	7.65	52	40.8
	8	83	0.8	0.1	3	7.5	8	78	0.025	9	7.68	44	42.7
	9	26	0.6	0.1	0.4	7.5	0.5	85	0.08	65	7.54	65	45.6
	10	90	0.8	0.1	4	7.5	12	63	0.11	6	7.49	70	48.3
	11	37	0.7	0.1	3	24	4	100	0.05	2.5	7.54	95	53.3
	12	50	0.7	0.1	2	37	5	80	2.3	2.5	7.61	50	55.2
	13	25	0.7	0.1	3	20	1	52	0.33	8	7.58	75	57.9
	14	10	0.6	0.1	1	7.5	0.5	86	0.025	2.5	7.7	60	60.4
	15	19	0.5	0.1	4	21	1	61	0.025	19	7.43	65	63
	16	40	0.5	0.1	3	24	2	58	0.025	8	7.42	60	65.2
	17	37	0.5	0.1	4	31	0.5	69	0.025	27	7.55	40	66.7
	18	30	0.6	0.1	4	17	0.5	43	0.025	24	7.9	40	68.3
	19	20	0.6	0.1	2	7.5	0.5	58	0.025	7	7.79	50	70.2
	20	24	0.3	0.2	3	26	0.5	63	0.025	14	7.79	60	72.5

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with "Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Preproduction

RESCAN Kutcho Creek SAMPLE 5026 - 3

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.464	7.70	461	25.0	0.0	8.6	0.4	185	8.6
2	14	0.405	7.48	747	21.1	0.0	7.5	0.7	285	20.1
3	21	0.404	7.69	391	18.1	0.0	21.6	1.6	140	25.8
4	28	0.348	7.28	374	16.8	0.0	2.4	1.7	135	30.5
5	35	0.484	7.56	319	23.0	0.0	7.1	2.0	100	35.3
6	42	0.405	7.75	195	25.0	0.0	1.9	2.1	80	38.6
7	49	0.438	7.65	200	22.1	0.0	8.6	2.5	52	40.8
8	56	0.432	7.68	266	18.6	0.0	8.6	2.8	44	42.7
9	63	0.436	7.54	202	17.2	0.0	4.0	3.0	65	45.6
10	70	0.389	7.49	246	16.5	0.0	4.0	3.2	70	48.3
11	77	0.525	7.54	292	21.2	0.0	1.8	3.2	95	53.3
12	84	0.375	7.61	205	17.5	0.0	2.0	3.3	50	55.2
13	91	0.370	7.58	214	16.0	0.0	2.3	3.4	75	57.9
14	98	0.404	7.70	176	19.5	0.0	1.7	3.5	60	60.4
15	105	0.406	7.43	196	15.7	0.0	2.1	3.6	65	63.0
16	112	0.366	7.42	181	18.6	0.0	0.7	3.6	60	65.2
17	119	0.384	7.55	195	17.6	0.0	1.4	3.6	40	66.7
18	126	0.382	7.90	144	15.8	0.0	1.2	3.7	40	68.3
19	133	0.390	7.79	177	17.5	0.0	1.1	3.7	50	70.2
20	140	0.388	7.79	180	17.5	0.0	1.1	3.8	60	72.5

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.

Humidity Cell Metal Analyses - Yr-5 (soil cover - prewashed)

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
YR-5(CW)	1	6	2.5	1	78	7.5	1	730	0.12	50	7.47	420	18.4
5026-4	2	13	36	0.5	54	7.5	1	190	0.07	7	7.47	270	28
	3	20	2.3	0.3	38	29	0.5	210	0.15	34	7.65	216	35.5
	4	40	3.9	0.1	44	31	0.5	120	0.08	12	7.45	149	40.6
	5	50	1	0.1	46	31	0.5	210	0.07	4	7.64	150	47.6
	6	16	1.4	0.1	8	7.5	0.5	82	0.06	6	7.55	150	52.6
	7	18	3.1	0.1	35	30	0.5	170	0.17	10	7.52	155	57.4
	8	36	1.1	0.1	14	7.5	1	51	0.14	2.5	7.34	53	59.2
	9	17	2.3	0.3	41	7.5	0.5	180	0.08	130	7.52	165	66.3
	10	76	2.4	0.1	47	7.5	2	82	0.18	10	7.47	115	69.8
	11	31	2.5	0.2	27	61	19	170	0.08	11	7.61	125	74.1
	12	23	1.9	0.1	14	30	2	190	0.05	10	7.46	160	79.8
	13	21	2.2	0.1	39	36	1	99	0.34	7	7.47	100	82.8
	14	12	1.5	0.1	54	7.5	0.5	100	0.1	2.5	7.49	85	85.3
	15	33	0.9	0.1	21	37	0.5	96	0.025	36	7.36	85	88.3
	16	25	1	0.1	17	7.5	2	90	0.025	10	7.58	85	91.1
	17	28	0.11	0.1	24	7.5	0.5	74	0.025	7	7.38	55	92.8
	18	24	1	0.1	24	7.5	0.5	66	0.07	19	7.69	55	94.6
	19	17	1.8	0.1	34	7.5	0.5	90	0.025	11	7.65	50	96.6
	20	23	1.1	0.1	24	33	1	110	0.025	18	7.61	90	99.5

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with "Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Yr-5 (soil cover - prewashed)

RESCAN Kutcho Creek SAMPLE 5026 - 4

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.438	7.47	1589	24.0	0.0	10.1	0.4	420	18.4
2	14	0.357	7.47	774	23.0	0.0	7.5	0.7	270	28.0
3	21	0.345	7.65	554	18.6	0.0	9.4	1.0	216	35.5
4	28	0.346	7.45	323	19.9	0.0	2.4	1.1	149	40.6
5	35	0.463	7.64	359	27.5	0.0	4.2	1.3	150	47.6
6	42	0.333	7.55	308	20.4	0.0	3.8	1.4	150	52.6
7	49	0.313	7.52	340	19.1	0.0	2.4	1.5	155	57.4
8	56	0.325	7.34	144	9.8	0.0	3.4	1.6	53	59.2
9	63	0.434	7.52	341	12.3	0.0	5.7	1.9	165	66.3
10	70	0.305	7.47	324	16.5	0.0	10.0	2.2	115	69.8
11	77	0.344	7.61	343	18.6	0.0	3.5	2.3	125	74.1
12	84	0.352	7.46	393	14.8	0.0	2.5	2.4	160	79.8
13	91	0.304	7.47	325	18.0	0.0	2.3	2.5	100	82.8
14	98	0.299	7.49	236	15.0	0.0	1.7	2.5	85	85.3
15	105	0.348	7.36	239	12.7	0.0	1.8	2.6	85	88.3
16	112	0.324	7.58	239	16.4	0.0	0.9	2.6	85	91.1
17	119	0.325	7.38	200	16.2	0.0	1.6	2.6	55	92.8
18	126	0.326	7.69	180	16.3	0.0	1.4	2.7	55	94.6
19	133	0.399	7.65	192	13.8	0.0	1.1	2.7	50	96.6
20	140	0.319	7.61	240	17.5	0.0	1.6	2.8	90	99.5

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.

Humidity Cell Metal Analyses - Yr-5 (no cover - prewashed)

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
YR-5(UCW)	1	11	0.3	0.4	0.5	7.5	0.5	330	0.025	11	7.55	210	8.7
5026-5	2	27	0.4	0.3	8	7.5	0.5	690	0.53	30	7.55	185	15.7
	3	11	0.6	0.1	2	7.5	0.5	240	0.24	17	7.73	150	21.5
	4	43	1	0.1	2	7.5	0.5	150	0.025	18	7.39	145	28
	5	55	0.9	0.2	2	7.5	0.5	130	0.025	6	7.63	150	35.1
	6	13	0.8	0.1	0.5	7.5	0.5	150	0.025	2.5	7.72	110	39.5
	7	8	1.5	0.1	2	7.5	0.5	150	0.71	9	7.44	60	41.9
	8	43	0.5	0.1	3	7.5	4	120	1.5	2.5	7.44	158	48.1
	9	18	0.3	0.1	2	5	0.5	150	0.06	76	7.39	95	52.2
	10	60	0.5	0.1	3	7.5	2	110	0.025	2.5	7.63	110	56.7
	11	29	0.8	0.1	3	20	2	150	0.07	2.5	7.49	160	64.7
	12	90	0.5	0.4	1	7.5	2	180	0.09	10	7.47	110	68.9
	13	17	0.6	0.1	2	17	1	110	0.025	8	7.58	100	73.1
	14	9	0.4	0.1	1	7.5	0.5	140	0.025	2.5	7.45	95	77.1
	15	11	0.4	0.1	4	7.5	0.5	91	0.025	13	7.45	90	80.8
	16	26	0.3	0.1	0.5	7.5	1	90	0.025	8	7.3	80	83.9
	17	18	0.4	0.1	3	20	0.5	94	0.025	2.5	7.38	95	88.2
	18	15	0.5	0.1	5	7.5	0.5	81	0.025	17	7.66	60	90.7
	19	11	1	0.1	1	7.5	0.5	92	0.025	6	7.7	60	93.3
	20	16	0.3	0.1	2	7.5	0.5	12	0.025	9	7.62	95	97.1

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with "Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Yr-5 (no cover - prewashed)

RESCAN Kutcho Creek SAMPLE 5026 - 5

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.413	7.55	525	20.5	0.0	10.1	0.4	210	8.7
2	14	0.380	7.55	522	22.1	0.0	9.4	0.8	185	15.7
3	21	0.386	7.73	414	19.6	0.0	6.1	1.0	150	21.5
4	28	0.449	7.39	372	18.4	0.0	1.9	1.1	145	28.0
5	35	0.470	7.63	361	24.5	0.0	8.9	1.5	150	35.1
6	42	0.407	7.72	298	21.4	0.0	9.9	1.9	110	39.5
7	49	0.392	7.44	226	14.7	0.0	10.1	2.3	60	41.9
8	56	0.392	7.44	292	14.7	0.0	10.1	2.7	158	48.1
9	63	0.429	7.39	278	15.8	0.0	6.2	3.0	95	52.2
10	70	0.413	7.63	297	15.5	0.0	9.0	3.3	110	56.7
11	77	0.500	7.49	407	18.0	0.0	2.0	3.4	160	64.7
12	84	0.384	7.47	302	15.1	0.0	2.5	3.5	110	68.9
13	91	0.418	7.58	253	16.5	0.0	1.5	3.6	100	73.1
14	98	0.416	7.45	258	15.0	0.0	1.2	3.6	95	77.1
15	105	0.414	7.45	246	13.2	0.0	1.3	3.7	90	80.8
16	112	0.395	7.30	229	14.3	0.0	1.0	3.7	80	83.9
17	119	0.450	7.38	266	14.7	0.0	1.4	3.8	95	88.2
18	126	0.418	7.66	186	15.0	0.0	1.3	3.9	60	90.7
19	133	0.429	7.70	210	16.6	0.0	1.0	3.9	60	93.3
20	140	0.405	7.62	245	16.6	0.0	1.1	3.9	95	97.1

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.

Humidity Cell Metal Analyses - Preproduction (prewashed)

SAMPLE	CYCLE	METAL ANALYSIS (ug/L) Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Zinc	pH	SULPHATE mg/L	CUMULAT. SULPHATE mg/100g
PPD(W)	1	26	0.6	0.4	1	7.5	0.5	390	0.025	15	7.62	270	12.3
5026-6	2	48	0.6	0.1	99	7.5	0.5	360	0.025	15	7.57	170	19.7
	3	52	0.5	0.1	3	7.5	0.5	120	0.025	21	7.82	140	25.4
	4	71	4.1	0.1	2	7.5	0.5	91	0.025	2.5	7.58	110	31.5
	5	94	0.9	0.1	3	7.5	0.5	70	0.025	9	7.67	105	36
	6	20	0.5	0.1	3	7.5	0.5	87	0.09	8	7.77	98	40.3
	7	19	1.2	0.1	2	7.5	0.5	63	0.12	2.5	7.6	70	43.7
	8	47	0.4	0.1	4	7.5	4	49	0.1	2.5	7.6	62	46.7
	9	36	0.6	0.1	4	7.5	1	84	0.1	73	7.46	98	51.5
	10	64	0.7	0.1	4	7.5	2	46	0.11	2.5	7.66	105	55.7
	11	52	0.7	0.1	0.5	28	4	63	0.05	2.5	7.54	50	58
	12	47	0.9	0.1	2	28	3	59	0.025	2.5	7.6	60	60.6
	13	27	0.8	0.1	3	17	2	48	0.025	2.5	7.67	40	62.3
	14	10	0.4	0.1	2	28	0.5	65	0.025	2.5	7.64	35	63.6
	15	19	0.3	0.1	4	17	0.5	42	0.025	11	7.43	40	65.2
	16	37	0.4	0.1	2	7.5	1	45	0.025	2.5	7.82	35	66.7
	17	27	0.3	0.1	3	7.5	0.5	43	0.025	11	7.62	35	68.2
	18	20	0.4	0.1	3	7.5	0.5	46	0.025	8	7.83	30	69.4
	19	16	0.9	0.1	2	7.5	0.5	45	0.025	5	7.92	25	70.5
	20	23	1.1	0.1	24	33	1	110	0.025	18	7.69	45	72.3

Metal Analyzed by ASL Laboratories, Vancouver, B.C.
Analyzed in Accordance with "Standard Methods of Examination of Water and Waste Water", American Public Health Association, 1985.

Humidity Cell Standard Analyses - Preproduction (prewashed)

RESCAN Kutcho Creek SAMPLE 5026 - 6

CYCLE	DAYS	LEACHATE VOLUME (L)	pH	CONDUCTIVITY (mS/cm3)	ALKALINITY (mg/L CaCO3)	ACIDITY (pH 4.5) --(mg/L CaCO3)--	ACIDITY (pH 8.3) --(mg/L CaCO3)--	CUM. ACIDITY (pH 8.3) (mg CaCO3/100g)	SULPHATE (mg/L)	CUMULATIVE SULPHATE (mg/100g)
1	7	0.457	7.62	599	22.0	0.0	11.0	0.5	270	12.3
2	14	0.431	7.57	514	18.6	0.0	9.9	0.9	170	19.7
3	21	0.408	7.82	368	23.0	0.0	5.6	1.2	140	25.4
4	28	0.560	7.58	271	23.5	0.0	2.8	1.3	110	31.5
5	35	0.428	7.67	245	30.1	0.0	7.5	1.6	105	36.0
6	42	0.436	7.77	208	24.0	0.0	12.2	2.2	98	40.3
7	49	0.478	7.60	149	15.7	0.0	2.9	2.3	70	43.7
8	56	0.486	7.60	167	17.2	0.0	2.9	2.5	62	46.7
9	63	0.489	7.46	164	18.5	0.0	2.6	2.6	98	51.5
10	70	0.407	7.66	174	17.5	0.0	3.0	2.7	105	55.7
11	77	0.454	7.54	175	18.6	0.0	1.5	2.8	50	58.0
12	84	0.437	7.60	185	9.0	0.0	3.5	2.9	60	60.6
13	91	0.411	7.67	146	17.0	0.0	1.7	3.0	40	62.3
14	98	0.394	7.64	133	16.0	0.0	1.7	3.1	35	63.6
15	105	0.383	7.43	168	14.7	0.0	1.2	3.1	40	65.2
16	112	0.443	7.82	125	20.1	0.0	0.7	3.1	35	66.7
17	119	0.410	7.62	126	16.7	0.0	1.0	3.2	35	68.2
18	126	0.428	7.83	109	18.0	0.0	0.9	3.2	30	69.4
19	133	0.422	7.92	116	16.1	0.0	0.8	3.3	25	70.5
20	140	0.393	7.69	149	18.9	0.0	1.2	3.3	45	72.3

COASTECH RESEARCH March 1990

Humidity cells were set up and monitored by Coastec Research Inc., N. Vancouver, B.C.